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VOLUME VII NUMBER 1

Report on the Starfishes of the West Indies, Florida, and Brazil

INCLUDING THOSE OBTAINED BY BAHAMA EXPEDITION FROM THE UNIVERSITY OF IOWA IN 1893

BY

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PUBLISHED BY THE UNIVERSITY, IOWA CITY

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VOLUME VII NUMBER 1

CONTENTS

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PUBLISHED BY THE UNIVERSITY
IOWA CITY, IOWA

Since several years have elapsed since the publication of the last report on material secured by the *Bahama Expedition* of 1893 from the State University of Iowa, it has been deemed advisable at this time to give a list of papers in which the results of the expedition are discussed, together with the full titles, authors and dates of issue.

Contribution to the anatomy of the Gorgonidae, together with observations on living specimens. Pages 97-160, and 10 plates. C. C. Nutting. Bull. Lab. Nat. Hist., S. U. I., Vol. I, No. 2. Nov., 1889

(This paper was based on material secured during a preliminary Expedition to the Bahamas by the author in 1888, and therefore should find a place here.)

Narrative and preliminary report of the Bahama Expedition. 251 pages, and 20 full-page illustrations. C. C. Nutting. Bull. Lab. Nat. Hist., S. U. I., Vol. III, Nos. 1 and 2. Jan., 1895

The mollusks and brachyopods of the Bahama Expedition of the State University of Iowa. 20 pages, and 1 plate. Wm. H. Dall. Bull. Lab. Nat. Hist., S. U. I., Vol. IV, No. 1. Dec., 1896

Notes on the Hymenoptera collected by the Bahama Expedition from the State University of Iowa. 4 pages. William H. Ashmead. Bull. Lab. Nat. Hist., S. U. I., Vol. IV, No. 1. Dec., 1896

Report on the fishes collected by the Bahama Expedition, of the State University of Iowa, under Professor C. C. Nutting. 20 pages. 4 plates. Samuel Garman. Bull. Lab. Nat. Hist., S. U. I., Vol. IV, No. 1. Dec., 1896

Report on the Actinaria collected by the Bahama Expedition of the State University of Iowa. 25 pages, 3 plates. J. Playfair McMurrich. Bull. Lab. Nat. Hist., S. U. I., Vol. IV, No. 3. June, 1898

The Brachyura of the expedition to the Florida Keys and the Bahamas in 1893. 65 pages. 9 plates. Mary J. Rathbun. Bull. Lab. Nat. Hist., S. U. I., Vol. IV, No. 3. June 1898

Report on the Ophiuroidea collected by the Bahama Expedition in 1893. 88 pages. 8 plates. A. E. Verrill. Bull. Lab. Nat. Hist., S. U. I., Vol. , No. 1. Sept., 1899

American Hydroids. C. C. Nutting. Smithsonian Institution, U. S. Nat. Museum, Special Bulletin No. 4, Part 1, issued 1900; part 2, issued 1904; part 3, issued 1915

(The writer, in undertaking to prepare this monograph, agreed to publish in it all descriptions of hydroids secured by the Bahama Expedition instead of issuing a separate Report on that group).

West Indian Starfishes found at a depth of 40 fathoms or less, including a report on material secured by the Bahama Expedition from the State University of Iowa. 230 pages, and 29 plates. A. E. Verrill. Bull. Lab. Nat. Hist., S. U. I. Vol. , No. , 1915

Descriptions of about 70 new species of marine invertebrates from the Bahama expedition collections are found in the papers listed above. Some important groups, such as the Echinoidea, Vermes, and Corals are still to be reported on; but it is hoped that the series will be complete at a reasonably early date.

The material upon which these papers are based is in the museum of natural history of the University.

C. C. Nutting

INTRODUCTION

That portion of this memoir relating to the special collection of the Bahama Expedition was nearly completed and the plates were made more than ten years ago, but its publication was delayed for several reasons, but largely because of the desirability of publishing, in advance of it, a much more extensive work, by the writer, on the starfishes of the North Pacific coast of America (Harriman Series) then in type, and in which the classification and many of the families and genera are revised.

Unavoidable and unexpected delay of the larger work had likewise delayed this. In the meantime, owing to the lack of any general work on the shallow water starfishes of the West Indies, and to the very scattered and unsatisfactory condition of the literature relating to them, it has been thought desirable to enlarge the report so as to include descriptions of all the families, genera, and species known to occur in the West Indian fauna, in waters less than 150 fathoms deep.

The West Indian faunal region is here extended so as to include the entire region from northern Florida to Rio de Janeiro, Brazil, and to include, also, the Bermudas and the whole of the Gulf of Mexico.

As compared with other tropical seas, the West Indian starfish fauna is very poor in littoral and shallow water species. It is rarely that more than twelve to fifteen species can be found by careful shore and reef-collecting at any one place.

Professor Clark (1898), after two seasons of shore and reef collecting of the echinoderms at Jamaica, enumerated only fourteen species of starfishes, although he visited both sides of the island, as well as outlying reefs. The entire number of littoral and very shallow water species probably does not exceed twenty to twenty-two over large areas.

This is not more than one-half or one-third the number to be found in many other similar regions.

At depths of 100 to 1,000 fathoms, however, the starfishes are very numerous, both in species and individuals.

The most prolific zone for starfishes, as well as for most other groups, is on the continental border in 100 to 500 fathoms.

The Bahama Expedition dredged at a number of localities between 100 and 200 fathoms, especially at the famous crinoid ground, off Havana, which is a locality very favorable for marine invertebrates of many kinds. Therefore, the collection obtained includes an unusual number of species, considering the small number of dredgings made, and the smallness of the equipment, as compared with that of the "Blake" or the "Albatross."

A few of the more common West Indian and conspicuous shallow water starfishes were mentioned by the early writers, such as Marcgraft (1648); Sloane (1725); Linck (1733); Seba (1761), and others.

This was especially the case with the very large and conspicuous species, the "large warted starfish" of Brown, 1756, now known as *Oreaster reticulatus*, which is very common in many places in very shallow water, and therefore sure to attract the attention of the most casual observers.

Yet the number of species actually known to occur in the West Indies was very small up to the period of Gray (1840) and of Müller and Troschel (1842).

Linné referred only two or three of his species to the West Indies and some of those doubtfully. Lamarck (1816) recognized only two or three as West Indian. Thomas Say (1825) recorded six species from the southern coast of the United States, five of which he described as new. All of these, except two, are also West Indian species.

Gray, 1840, gave the West Indian region as the source of eight of his species. Müller and Troschel (1842) recorded but five as West Indian, though they described others from this fauna whose origin was unknown.

The first attempt to give a critical synopsis of the West Indian species was made by Prof. Christian Lütken,[1] a most careful

[1] Dr. Christian Frederik Lütken, professor of the University of Copenhagen; lieutenant in the war of 1849-50; died February 6, 1901, aged 73 years.

His works on the starfishes and ophiurans of northern Europe, Green-

writer, in 1859. He then described with care thirteen species, in the Museum of Copenhagen, mostly from the Lesser Antilles. Six were described as new, mostly with doubt. At least four of these proved to be synonymous with those of Gray and other previous writers, who had poorly described them. His careful descriptions are, however, invaluable for the determination of most of the early known species, and mark an era in work of this kind.

In 1867 the present writer published a faunal list of West Indian species, for comparison with that of the Panama region. This list included twenty-four nominal species, but at least five of these have since become synonymous. On the other hand, two or three previously described species were omitted. Thus the number of species of this fauna actually known at that time was about twenty.

The beginning of dredging in somewhat deep water was made by Pourtales in 1867 and 1868, but only one additional species of starfish was then added by him.[2] Subsequently, these investigations were carried on by the "Bibb," in 1869, and the "Hassler" in 1872, under the direction of Pourtales, and in 1872, under Dr. Wm. Stimpson by the "Bibb" and "Bache." But no separate lists of the starfishes taken in those years has been published. Some are included in the "Revision" by Perrier, 1875 and 1876 (see Bibliography); others in his 1884 report on the Blake starfishes.

Mr. Alexander Agassiz carried out his extensive dredgings in the Caribbæan Sea and Gulf of Mexico, etc., on the "Blake" in 1877, 1878, 1879, and 1880. About 350 stations were occupied by the Blake.

These explorations[3] added numerous species of starfishes to the fauna, not only from great depths, but also many from comparatively shallow water.

The starfishes thus obtained by Agassiz were described by Per-

land, and both coasts of tropical America are classical and indispensable. He also wrote on fishes, ascidians, actinians, and other subjects.

For many years he was a most esteemed correspondent of the writer.

[2] Catalogued by Agassiz as *Pteraster militaris*, now called *P. caribbæus* Perrier.

[3] A very complete and interesting account of these explorations is given by Mr. A. Agassiz in "Three Cruises of the Blake." Vols. I, II. 1888.

rier in several articles from 1880 to 1894, but most were brought together in his memoir of 1884.

Dredging operations of great extent were carried on by the U. S. Fish Comm. steamer "Albatross," in the West Indian region during the winters of 1884, 1885, and 1886.[4] Many species of starfishes were then obtained, including a considerable number of new species. But those collections have not yet been systematically reported upon, though the writer described and figured a number of the species in 1899.

According to Mr. A. Agassiz (1888, p. 4), the Blake took 54 species of starfishes, of which 46 were considered new species by Perrier. The actual number has since proved to be slightly larger.

The Bahama Expedition, from the University of Iowa, dredged mostly in waters less than 200 fathoms deep. The most interesting were off Havana, on the crinoid grounds, where a number of additions to the starfish fauna were taken. Others of interest were from off E. Florida, on the "Pourtales Plateau." The total number of species taken was about thirty.

In consequence of these more modern dredging expeditions the number of species of West Indian shallow-water starfishes, living in less than 150 fathoms, has been very much increased, while the deep-water species have become even more numerous.

I have had opportunity to examine most of the types of the "Blake Expedition" starfishes, described by Perrier, and also many of those taken in the West Indies by the Albatross. But I have not had opportunities to make any thorough studies of the latter as a whole, and, therefore, can not give any useful statement as to the number of additions to the fauna contained in them. Some of the species from the Albatross explorations were revised, and a number of new species were described and figured by me in 1899. (Revision of Genera and Species of Starfishes, see Bibliography.)

At present about 125 species are known to me from that general faunal region, or from Florida to Brazil. Of these about 42

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[4] Lists of all the dredging stations occupied by the Albatross, Blake, and other U. S. vessels up to 1887, with physical data, were published by Sanderson Smith, in the Annual Report of the U. S. Fish Commission, for 1886, pp. 873-1014.

species have not been taken in less than 150 fathoms, and several are still undescribed.

Some of the West Indian shallow-water species have a wide range. A few range from Florida to the Abrolhos reefs, Brazil, or to Bahia. Two or three are said to be found on the West Coast of Africa, or at the Cape Verde Islands. Four reach Bermuda. None are identified with those of Panama, though some are closely related. Among the deep-water species a few have been taken also off the eastern coast of the United States, north of Cape Hatteras, and three or four are thought to be identical with East Atlantic species from similar depths. Yet most of the species are peculiar to this fauna.

Very little is known concerning the starfishes to be found on the extended coasts of the Gulf of Mexico, beyond the coasts of western Florida and Alabama. Mr. Ives has listed several species from Vera Cruz and Yucatan. Two are peculiar to Vera Cruz, so far as known. Yet there are more than two thousand miles of that coast line about the marine fauna of which we know almost nothing.

That coast is almost everywhere sandy, and therefore not favorable to many shallow-water invertebrates, except in sheltered localities.

It is known, however, that several of the Florida species reach Vera Cruz and Yucatan; others reach Colon. I can now add that one species (*Astropecten americanus*), common at moderate depths north of Cape Hatteras, occurs at similar depths on the northern coast of Colombia.

The Brazilian species are here included, because several, or the majority, are identical with West Indian and Florida species. The Brazilian starfishes have been listed by Mr. Richard Rathbun, 13 species (1879), and later by Ludwig, 1882. At least nine or ten of the Brazilian species occur also in the West Indies.

In this report all those species which are known to have been obtained in less than 150 fathoms are included, though a number of them really belong to the deeper water series, but find their upward limits in 100 to 150 fathoms. Doubtless other deep-water species will hereafter be found at such depths, especially the young. A few other deep-water species have been included for the sake of comparisons with their shallow-water allies.

It is proposed to include, at the end, a special list of the other deep-water species (about 40) not reported upon, for the sake of completeness.

Thus the systematic part of this report will include about 82 species and subspecies, nearly all of which are redescribed in detail, with their known distribution, etc.

Comparatively few, even of the shallow-water species, have ever been figured. Therefore some of them, though not new, have been figured in this report.

The drawings of structural details are by A. Hyatt Verrill, and also most of the photographs.

Class ASTERIOIDEA

MORPHOLOGICAL FEATURES

The Asterioidea [5] have a polygonal or star-shaped body, in which the rays are direct prolongations of the body itself, and contain extensions of the body-cavity and more or less of the viscera, especially one or more pairs of gonads and a pair of digestive glands; generally, also, a lobe of the saccular stomach.

The actinal or ventral side of the disk and rays has deep, radial, ambulacral grooves, extending to the tips of the rays. The roof of the groove is supported by two rows of ambulacral ossicles, arranged like rafters, or in close, inverted, V-shaped pairs of plates or bars, between which are rows of pores for the passage of the tubular ambulacral feet or "podia," which are usually terminated by a muscular sucker, but are pointed in the suborder Paxillosa.

In the middle line of each ray and external to the ambulacral plates are situated the radial nerve and blood-vessel; and deeper within, the median radial "water-tube" or ambulacral tube. The radial water-tube supplies water to the podia through the medium of muscular ampullæ situated internally, above the ambulacral plates. Usually there are two of these to each podium, but in *Echinaster, Ctenodiscus,* and some other genera there is only one.

The grooves are bordered on each side by a row of plates called adambulacral, which always bear spines.

[5] This spelling of the name is preferred because it is derived from *Asterias* (not from *Aster.*)

The mouth is central, dilatable, and surrounded by soft membrane. The so-called jaws are merely the adoral ambulacral and adambulacral plates, more or less modified and coalesced. The "teeth" are only slightly modified adambulacral spines.

The stomach is very saccular and usually evertible. It usually has a lobe and a pair of digestive glands extending into the cavity of each ray, but in the case of some multiple-rayed species (*Heliaster*), it has lobes corresponding only to the primary five rays. In this case the five stomach-lobes do not enter the rays, but the five pairs of digestive glands do. In a few slender-rayed genera, also, the stomach is confined to the disk. The intestine is rudimentary or abortive, and not functional in most cases; usually there is a median dorsal nephridial or "anal" pore, mainly for the discharge of the secretions from a lobulated gland.

The respiration is partly dermal, but especially by tubular dermal outgrowths, called papulæ. The madreporic plate is dorsal, usually single, but sometimes two or more are present in autotomous species. The rays terminate in an enlarged apical or ocular plate, carrying an ocellus.

The skeleton is made up of large numbers of ossicles and plates of various kinds, mostly articulated so as to be more or less movable, giving flexibility, both to the rays and to the disk, though in some species (e. g. certain Goniasteridæ) the flexibility is slight, except at the tips of the rays.

The external skeletal plates are classed as dorsal or abactinal; marginal; interactinal; adambulacral; ambulacral; oral; and ocular or apical. The dorsal plates are very diverse in form and arrangement. They may be irregularly reticulate, tesselated, or imbricated. They may form regular radial rows; sometimes they are abortive, or nearly so. They are concealed by a thick dermis in certain genera.

The dorsal plates, like the marginals and interactinals, commonly bear spines or small spinules, but they may be covered with granules, or with a smooth soft integument, or even appear quite naked, being then covered only with a thin membrane.

These plates and their armatures of spinules take several special names, according to their forms and structure, and are often characteristic of special genera and families and higher groups.

When they become columnar or of hour-glass shape, and have the summit covered with a radiating cluster of small slender spinules, they are called paxillæ. These are the most typically formed in *Astropecten, Luidia,* and allied genera, and are characteristic of the suborder Paxillosa.[6]

In nearly all the families there are two rows of specialized plates on each side of each ray, known as superomarginal and inferomarginal plates. These are often the largest and most conspicuous of all the plates, especially in the Phanerozona, such as *Astropecten, Goniaster,* etc. In other cases both rows are much reduced in size and are not easily distinguished, as in some of the Asteriidæ. Or only the upper row may be reduced and indistinct, as in *Luidia.* Rarely one or both rows are abortive in certain deep-sea genera. Secondary intermarginal rows of plates are often interpolated between the marginal rows in some families.

Between the inferomarginals and the adambulacral plates there may be one or more rows of plates called *interactinals.* The first and most important of these is next the inferomarginal row, and is called the *peractinal row* in this article. It may extend nearly or quite to the tip of the Ray. The other rows are called *subactinal rows,* and may be much shorter and later formed. All these interactinal rows may be lacking in many genera, or they may be rudimentary and spineless.

They appear later in development than the marginal plates, and the new ones are not formed next the ocular plates, as are the marginals.

Pedicellariæ of one or more kinds are generally present, but are rare or entirely lacking in certain families, such as the *Solasteridœ, Echinasteridœ, Pterasteridœ,* and in some genera of other families. Their uses are imperfectly known. One use it to keep the body free from dirt and parasites.

These curious organs are not found in other classes of Echinoderms, except in the Echinoidea. In the latter they are commonly mounted on long stalks and generally have three valves — sometimes four or more or only two.

In the Asterioidea they are usually sessile, but in the order

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[6] For various other special forms and their names, see below, under Phanerozona and Valvulata.

Forcipulosa they have very short pedicels, and they are most frequently bivalved.

They are of several different types, which are commonly characteristic of the orders and families, and often of the genera.

Sometimes there may be bivalved, trivalved, four-valved, and five-valved ones on a single specimen, as in *Dermasterias imbricata.* In some cases they are not really valvular, but consist of several movable spinules, arranged in convergent groups or opposed rows. The sessile valvular forms are generally situated over a pore, penetrating a plate, for the passage of nerves, etc.

Some of the special forms are described below, under the several orders.

In nearly all species there are numerous small, soft, tubular outgrowths from the body-wall, called *papulæ,* serving for respiratory purposes. They may be in large groups, especially between the dorsal and lateral ossicles, or stand singly, or they may occur only in special areas. Rarely they are branched, as in *Luidia.*

Most shallow-water starfishes that have been studied in this respect have a free-swimming, bilateral larval form, known as a brachiolaria. A considerable number carry their eggs and young till they develop the starfish form. These have an abbreviated metamorphosis. The two methods may occur in different genera of the same family (e. g., *Asteriidæ*).

The embryology of the deep-sea species is unknown in most cases, and may be diverse, or even more abbreviated.

CLASSIFICATION OF ASTERIOIDEA.

In this report I have adopted the division of the class into three large orders, viz.:

I. FORCIPULOSA or FORCIPULATA.

II. SPINULOSA, with suborders, AVELATA and VELATA.

III. PHANEROZONA.

The last has three suborders, considered orders by some writers, viz.:

I. VALVULOSA or VALVATA.

II. NOTOMYOTA Ludwig (as an order).

III. PAXILLOSA.

Order Forcipulosa Verrill or Forcipulata Perrier.

Stelleridæ forcipulatæ Perrier, Mem. Etoiles de Mer, pp. 166, 188, 1876.
Forcipulata Perrier, Exped. Sci. Trav. et Talisman, p. 27, 1894.
Asteries Ambulacraires Viguier, Squellette des Stellerides, Arch. Zoöl. Exper., VII, p. 93, 1878.
Cryptozonia (*pars*) Sladen, Voy. Chall., xxx, pp. xxxiv, 397, 1889.
Adetopneusia (*pars*) Sladen and *Leptostroteria* (*pars*), op. cit., p. xxxiv.
Forcipulosa Verrill, op. cit., p. 24, 1914*a*.

In this order the form is always stellate, often with long rays, commonly five, but often multiple. Ambulacral plates, except the orals, are usually short and closely crowded (*leptostroterial*), but not in *Brisingidæ.* The proximal pair is elongated and, except in *Pedicellaster* and a few others, forms the inner end of the jaw. Ambulacral feet are generally arranged in four rows; but in two rows in *Pedicellasteridæ, Brisingidæ,* and *Zoroasteridæ.* In certain large species of *Pisaster* there may be more than four rows.

Aside from the ambulacral and adambulacral plates, the skeleton of the rays consists of five fundamental or primary rows of ossicles, viz., the *median dorsal* or *carinal*; the two *superomarginals*; and the two *inferomarginals.* The latter may or may not be confined to the ventral side.

The ossicles of adjacent rows may be articulated directly by their lobes, or small, simple *connecting ossicles* may intervene.

This simple or primitive type of skeleton is found in *Coronaster briareus* (see pl. ix, fig. 4) and some other genera, especially when young.

In most cases more or less numerous ossicles or rows of ossicles are interpolated during growth between the five primary rows, either above or below, or between the marginals, thus giving rise to many different styles of skeleton in the more complex genera.

The carinal or median dorsal plates usually remain distinct, but are often small and not easily recognizable. The two marginal rows are nearly always easily recognizable, though small, and they generally bear spines larger than the dorsals. They never form a stout margin, as they do in the Paxillosa.

Interactinal plates are various. Usually there is at least one row, the peractinals, but these are often small and spineless and sometimes are lacking. In other genera there may be several rows of spiniferous interactinals.

The Forcipulosa, as the name implies, are specially characterized by the possession of forcipate pedicellariæ, not found in other orders. Two forms of pedicellariæ are nearly always present, except in the young.

The minor or forcipulate pedicellariæ, peculiar to this order, generally form wreaths or large or small clusters on the spines, but they may also occur, either singly or in clusters, on the integument of the dorsal or lateral plates, on the papular areas, and in other situations. Their two blades are prolonged proximally and crossed, with muscles attached to the ends, so that they can open and shut like forceps or scissors. Their valves are concave and are usually armed with denticles.

The major or forficulate pedicellariæ are generally ovate or lanceolate, sometimes wedge-shaped, stone-hammer-shaped, lyrate, or spatulate. The tips may be acute, plain, flat or denticulate.

They are mostly dermal, but may also occur on the ventral and oral spines, or along the inner edges of the grooves, or attached to pedicels in clusters within the grooves, or even on the pedicels of the ambulacral feet. They may be of several sizes and forms on one specimen.

Certain species of *Asteriidæ, Coronaster*, etc., have a peculiar very large form of dermal pedicellariæ, often as thick as the spines, in which the broad valves terminate in a series of curved denticles, so that when closed the valves resemble a pair of clasped hands, or better still, a pair of clasped feet of a cat, with the claws protruded. These may be called *felipedal* or *unguiculate*. (See pl. ix, fig. 4*c*.)

FAMILIES AND SUB-FAMILIES OF FORCIPULOSA.

This order now includes the following families and sub-families:

I. Family ASTERIIDÆ.

Subfamilies ASTERIINÆ; STICHASTERINÆ; PYCNOPODINÆ; HELIASTERINÆ.

II. Family ZOROASTERIDÆ.

III. Family PEDICELLASTERIDÆ.

IV. Family BRISINGIDÆ.

Subfamilies BRISINGINÆ; LABIDIASTERINÆ (Type, *Labidiaster* Lutk.).

The first three families are represented in depths less than 150 fathoms, though all except the first family are essentially deep-sea groups.

Family Asteriidæ Gray (emended).

Asteriidæ Gray, Ann. & Mag. Nat. Hist., vi, p. 178, 1840; Synopsis, p. i, 1866. Perrier, Revis. Stell., Arch. Zoöl. Exper. et Gen., iv, p. 302, 1875; Mem. Etoiles de Mer, pp. 167, 198, 1876. Viguier, Squellette des Stellerides, pp. 93, 99, pl. v, figs. 1-10, 11-12, 1878.

Asteriidæ (emended) + *Stichasteridæ* Sladen, Voyage Chall., xxx, pp. 430, 560, 1889. Perrier, Exp. Trav. et Talisman, pp. 43, 105, 107, 128, 1894; Contrib. l'étude des Stellerides Atlan. Nords, pp. 25, 31, 1896. Verrill, Monog. Starfishes, North Pacific, pp. 27-44, 1914*a* (emended.)

Stellate starfishes, most often with five or six elongated rays; sometimes with a variable number of unequal rays in autotomous species; sometimes with numerous rays, increasing with age by the outgrowth of interpolated rays, as in *Heliaster* and in *Pycnopodia*. Madreporic plate generally single in five-rayed and six-rayed forms, but often two or more in those with a variable number of rays, due to autotomy or budding. Dorsal and actinal plates various in form and arrangement, most often reticulated. Odontophore usually formed of a single piece. Oral ambulacral plates elongated and forming the jaws. Those along the grooves become very short and compressed. Papulæ occur both on the actinal and dorsal sides. Ambulacral feet usually crowded in four rows, sometimes more. Pedicellariæ of two kinds are present. Dorsal plates generally bear spines or spinules, various in size and kind, and sometimes granules. They are never true paxillæ.

The minor pedicellariæ may be attached directly to the integument, either singly or in clusters, or to the spines, to the pedicels of the larger forms, to saccular dermal growths around the spines, to the inner edge of the ambulacral grooves, or rarely even to the ambulacral feet. They are most commonly attached by slender and sometimes long pedicels, and aggregated into wreaths or clusters attached to a contractile fold of dermis on the spines. They are often so abundant, in the wreaths around the dorsal spines, that they nearly or quite conceal the spines and integument in living specimens. In some cases they are attached in large numbers to large muscular dermal sheaths or

sacks loosely surrounding the spines nearly or quite to the tips when extended in life. They often have a formidable array of minute sharp denticles, and are frequently very characteristic of species.

Subfamily ASTERIINÆ.

Asteriidæ (restr.) Sladen, op. cit., 430, 560, 1889. Perrier, 1894, pp. 105, 128; 1896, pp. 25-31.
Asteriinæ Verrill, op. cit., p. 42, 1914a.

The *Asteriinæ* are chiefly characterized by the more or less openly reticulated arrangement of the dorsal and lateral ossicles, especially of the dorsal ossicles, which are usually more stellate or lobulate and more slender than in the *Stichaster* group, and generally united either by the ends of the lobes or apophyses, or else by means of interpolated ossicles, thus allowing more flexibility in the rays, and larger papular areas. The dorsal plates may be in definite rows or irregularly reticulated.

The *Stichasterinæ*, on the contrary, are chiefly characterized by the more or less regular subtesselated or imbricated arrangement of the ossicles, both on the sides and dorsal surface of the rays, the ossicles themselves being larger, broader, and more rhombic, and usually united in more definite, longitudinal and transverse rows, with smaller and more regular intervening papular areas. In either group, as at present understood, the interactinal plates may have the regular serial and subtesselated arrangement.

The discovery of many new generic and specific types intermediate between typical *Stichaster* [7] and *Asterias*, renders it difficult to define the limits of the two so-called families, typified by these genera.

The only West Indian genus that has been referred to the Stichasterinæ is *Stephanasterias*. To me this seems to be more nearly related to *Leptasterias* and therefore one of the Asteriinæ.

Genus ORTHASTERIAS Verrill.

Orthasterias Verrill, Starfishes North Pacific, pp. 168-185, 1914a.

Long-rayed diplacanthid starfishes with a small disk. Dorsal

[7] The type of *Stichaster* is *S. striatus M.* and Tr. = *S. aurantiacus* of later writers. It is a Chilian species.

skeleton consists of lobed, wide, subimbricated or contingent plates, arranged in three, five, or rarely more regular radial rows, and sometimes with extra interpolated ossicles; the rows are connected by transverse ossicles. The principal plates bear, on a central boss, large, isolated spines, usually making three or five longitudinal rows above the marginal rows.

Superomarginals are large, usually monacanthid, four-lobed; the descending lobe is large and usually joined directly to the inferomarginals.

The inferomarginals are strong, convex ossicles, each bearing usually two large spines.

Uusually there is one row of interactinal plates, with or without spines, closely united to the adambulacrals and inferomarginals; sometimes they are rudimentary and without spines. (*Stylasterias.*)

Papulæ are numerous and clustered.

The lateral and dorsal major pedicellariæ are large, and are usually of two or more forms. The larger are erect, wedge-shaped, stone-hammer-shaped, or ovate, with the tips of the valves wide and usually denticulate. Others are more slender, with the valves spatulate or narrowed in the middle and the tips unguiculate, with interlocking teeth. Others similar, or smaller, with acute tips, often occur on the adambulacral spines and margin. Type, *O. columbiana* V.

This genus includes several large species on the North Pacific coast. Off the eastern coast of the United States one species (*O. tanneri* Ver.) is abundant at moderate depths, from south of Cape Hatteras to southern New England.

The subgenus *Stylasterias* Ver. (op. cit., p. 48, 1914*a*), was separated mainly because it has only rudimentary and spineless interradial plates, which are not visible without preparation.

The following West Indian species belong to this group or subgenus. The young of *O. tanneri*, when two or three inches across, have the same features.

ORTHASTERIAS SUBANGULOSA Verrill.

Asterias angulosa Perrier, Bull. Mus. Comp. Zoölogy, vol. ix, p. 3, 1881; Mem. Etoiles de Mer, p. 202, 1884 (*non* Müller.)

Orthasterias (*Stylasterias*) *subangulosa* Verrill, Starfishes N. Pacific Coast, pp. 168, 370, 1914a.

Plate ii; figures 1, 2. Plate ix; figures 1, 1*a*.

The largest specimen has the radii 9^{mm} and 66^{mm}; ratio, 1:7.33. This was from the Bahama Expedition, station 43, in 15 fathoms. The disk is small and has a very evident central pentagon of plates and spines. The rays are slender, somewhat angular, regularly tapered to subacute tips.

The dorsal plates form a conspicuous raised median carina, and a smaller dorso-lateral row on each side, well separated from the prominent superomarginal row by a wide lane, containing large papular areas and crossed by stout transverse ossicles uniting the plates of the two rows, but without spines.

The spines generally stand singly on all the dorsal, radial, and superomarginal plates, and all have the same form. They are rather long, terete, regularly tapered, and acute. They are surrounded, near the base, with a dense wreath of minor pedicellariæ of small size.

The inferomarginal plates form a conspicuous row well separated from the upper ones by a wide lane, which contains a row of large papular areas and bears many rather large, erect, lanceolate or subacute major pedicellariæ.

Each plate usually bears two spines, one nearly above the other. The upper one is the larger. It is larger than the superomarginals and dorsals, and is somewhat flattened, often a little expanded distally or sublanceolate, and subacute; the other is distinctly smaller and more acute. Sometimes there is proximally a much smaller third spine below the second, apparently arising from the same plate, but perhaps, in some cases, arising from a rudimentary interactinal ossicle not visible at the surface. The third spine is lacking in specimens a little smaller.

The upper inferomarginal spines bear, at about midheight, a dense cluster of numerous minor pedicellariæ on the upper side. There are also some of the rather large lanceolate major pedicellariæ between their bases. Similar major pedicellariæ occur on and between the adambulacral spines, on the inner margins of the ambulacral furrows, and on the interradial areas.

The adambulacral plates bear each two rather long, slender, flattened, subequal spines, which form two regular rows; the and more flattened or subspatulate. The peroral spines are outer ones are the larger. The adoral spines are longer, larger,

rather stout and blunt. It appears to be the undetermined starfish described by Nutting (Narrative Bahama Exped., bottom of page 168). This species was dredged by the Bahama Expedition at station 43, off Sand Key, Florida, in 15 fathoms; at station 47, off Key West, in 80 fathoms; and at station 61, off Key West, in 75 to 80 fathoms. Several specimens were obtained. Perrier recorded it from the Blake stations, off Florida, in 85 and 110 fathoms, one from each place. The type had the radii 6^{mm} and 43^{mm}.

Orthasterias contorta (Per.) Verrill.

Asterias contorta Perrier, Bull. M. C. Z., vol. ix, p. 1, 1881; Mem. Etoiles de Mer, p. 199, 1884.
O. contorta Verrill, op. cit., p. 48, 1914*a*.

This species was not figured by Perrier and only imperfectly described. The size was not given. I did not examine his cotypes, in the Museum of Comp. Zoölogy, except in the case of a single lot of small specimens (sta. 155, 88 fathoms). These appeared to me to be the young of *O. subangulosa.*

According to Perrier's description it has no dorsal rows of plates except the carinals, which might be due to immaturity. He also mentions that the submarginal papulæ are large and placed singly. In *O. subangulosa* they are rather small and stand two or three together.

Without farther study of the types it is not possible to say whether they are distinct species.

Perrier recorded this from ten Blake stations, in 11 to 188 fathoms, from Florida reefs to Cariacou and Barbadoes.

Genus Coscinasterias Verrill.

Cosinasterias Verrill, Trans. Conn. Acad. Sci., i, p. 248, 1867. (Type, *C. muricata* V. = (?) *C. calamaria* (Lam.).)
Stolasterias (*pars*) Sladen, Voyage Chall., vol. xxx, pp. 563, 583, 1889. (Type, *C. tenuispina.*) *Non* Perrier.
Coscinasterias and *Polyasterias* Perrier, Exped. Trav. et Talisman, p. 108, 1894.
Coscinasterias Verrill, op. cit., pp. 45, 46, 1814a.

Disk small, rays elongated, somewhat angular, usually carinate. Dorsal plates of the rays stout, four-lobed, usually arranged in three or five regular rows, besides the upper marginals, which form regular lateral rows. Interactinal plates form one primary

(peractinal) row, like the lower marginals, but they may be rudimentary and spineless in half-grown specimens, and only bear spines in large, mature individuals, as in *C. tenuispina.*

Minor pedicellariæ are abundant. Large forficulate or major pedicellariæ of the usual forms are present, often in considerable numbers, on the dorsal and lateral plates, and smaller ones occur on the marginal areas. Large unguiculate pedicellariæ are lacking. Adambulacral plates are monacanthid or nearly so.

Stolasterias, which was proposed as a subgenus by Sladen in 1889, was nearly identical with *Coscinasterias*, characterized by me in 1867. He gave no reason for changing the name. It should be regarded as a synonym of the latter and be eliminated. Sladen's type was *A. tenuispina*, which is a *Coscinasterias* with the interactinal plates rudimentary and without spines, except in the larger specimens.

As *C. tenuispina* often divides spontaneously, it belongs to *Polyasterias* in Perrier's arrangement. This would make the latter strictly synonymous with Sladen's typical *Stolasterias.*

M. Perrier (1894) correctly retained *Coscinasterias* for the typical forms, like *calamaria*, but separated those species that are known to undergo spontaneous fission under the name of *Polyasterias* = typical *Stolasterias* Sla., though they do not appear to differ much in structure from the preceding. He retained *Stolasterias* Sla., in a restricted sense, for those allied to *glacialis*, although *C. tenuispina* was named by Sladen as the type.

A. glacialis had, long before, been made the type of *Marthasterias* by Julien.

Coscinasterias tenuispina (Lam.) Ver.

Asterias tenuispina Lamarck, op. cit., 1816, vol. ii, p. 561. Perrier, Revision, op. cit., p. 306, 1875.

Asteracanthion tenuispinus Müll. and Trosch., Syst. Asteriden, p. 16, pl. i, fig. 1, *a. b.*, 1842. Perrier, Pédicellaires, p. 32, pl. i, figs. 3-3c, 1859. Lütken, op. cit., 1859, p. 95.

Asterias (*Stolasterias*) *tenuispina* Sladen, pp. 565, 583, 1889. Verrill, The Bermuda Islands, vol. ii, part v, p. 324, in Trans. Conn. Acad. Sci., vol. xii, p. 280, plates xxxiv, fig. 2; xxxiv c, fig. 2, 1907.

Coscinasterias tenuispina Verrill, op. cit., 1814a, p. 45.

Asterias atlantica (*pars*) Verrill, Transactions Conn. Acad. Sci., vol. i, p. 368, 1868. R. Rathbun, Brazilian Echinoderms, in Trans. Conn. Acad., vol. v, p. 144, 1879.

Plate xxvi; figure 2. Plate xxvii; figure 4.

Disk small. Rays long, rather slender, angular, variable in number. Dorsal and marginal spines are elongated and rather slender. Adambulacral spines slender, one to a plate. Color in life usually pale purplish or violaceous above, yellowish below.

This species is autotomous and therefore is commonly found with the rays unequal and variable in number, from two or three to nine or more, but most frequently with six to eight, three or four being often much shorter than the others. There are usually two or more madreporic plates. Sometimes it is regularly six-rayed or five-rayed. It becomes six to eight inches in diameter at the Bermudas.

The dorsal plates are rather openly united and form a definite median or carinal row and one main dorsolateral row on each side, often with one imperfect second row proximally in large specimens. Each dorsal plate usually has a rather strong, somewhat elongated spine.

The superomarginal row of plates is well marked and forms the lateral margin of the ray. Each plate bears one, or sometimes two, elongated spines, longer than the dorsals. The superomarginals are also strongly developed and have a row of large spines close to the adambulacrals.

The interactinal plates are small and usually without spines, but in very large specimens some of them may bear a small spine.

The adambulacral plates normally bear one long slender spine, but in very large specimens a few bear two spines. In life the color varies. It is usually some light shade of violet or pale purple; yellow below.

This is a common Mediterranean species. It has been reported from Madeira, the Canary Islands, Cape Verde Islands, Brazil, Abrolhos Reefs, Brazil (coll. C. F. Hartt, Yale Mus.), Cuba, the Bermudas, and West Indies. It is the only common starfish at the Bermudas.

It is well adapted, by its habits, to be carried from one country to another, adherent to the bottoms of vessels.

Coscinasterias tenuispina, var. atlantica Verrill.

Asterias atlantica (*pars*) Verrill, Corals and Echinod. of Brazil, Trans. Conn. Acad. Science, vol. i, p. 368, 1868.

One of the types of this supposed species was a regularly five-rayed specimen from Cuba. It differs sufficiently from the ordinary form of the species to receive a varietal name, and therefore I propose to designate it as above.

The rays of the type of this form are decidedly angular, relatively shorter and stouter than in the ordinary form. The median radial and two marginal rows of spines and plates are strongly developed, and one dorso-lateral row is less so. The adambulacral spines are monacanthid, as in the typical form. The dorsal and marginal spines are shorter and stouter than in the latter.

The type was from Cuba. I am not prepared to say that the other American forms are fully identical with those of Europe, for I have never been able to study a good series of both in any museum. Valid specific characters may have been overlooked by authors who unite them.

Coscinasterias linearis (Perrier) Verrill.

Asterias linearis Perrier, op. cit., p. 2, 1881; Etoiles de Mer, p. 201, pl. iii, fig. 5, 1884.

The type of this species is small and evidently young. It is monacanthid and evidently a *Coscinasterias*. It may, perhaps, prove to be the young of *C. tenuispina* when a good series can be studied.

The type had the radii 5^{mm} and 50^{mm}; ratio, 1:10. The rays are five, slender, angular. The dorsal side of the rays has three rows of plates, each of which bears a single elongated spine, thus forming three longitudinal rows of spines. There are three rows of ventral spines. The outer one forms the lateral, larger (inferomarginal) row of spines. Between these and the upper lateral row are large isolated papulæ; on the dorsal side the papulæ are smaller and clustered. There appear to be two rows of interactinal spines proximally. Major pedicellariæ, elongated in form, were found on the disk.

Adambulacral spines are one to a plate. They are straight and not tapered. (Condensed from Perrier's description.) The type was from Blake station 45, in 101 fathoms, off West Florida.

Genus Leptasterias Verrill.

Leptasterias Verrill, Proc. Boston Soc. Nat. Hist., x, p. 350, 1866. Type, *A. mülleri* Sars. Sladen, Voy. Chall., xxx, p. 563, 1889. Perrier, Exp. Trav. et Talism., p. 108, 1894. Verrill, op. cit., p. 116, 1814a.

An extensive group of small, more or less diplacanthid starfishes, closely related to typical *Asterias*, usually with a single row of peractinal plates and spines. Rays five or six. The more typical forms have slender rays and a small disk, with the dorsal ossicles irregularly arranged, or showing several imbricated radial rows, with numerous spines. It differs from typical *Asterias* in the diminished number and larger size of the dorsal and lateral papulæ, and the small number of actinal plates, of which there is generally only a single row, but more profoundly in having the genital pores on the actinal side, near the mouth, and in the ovaries, which are different in form and produce larger eggs, which have an abbreviated development, passing through no free-swimming larval stages.

The eggs and young are carried in clusters, adhering in front of or around the mouth in all the species studied in the breeding season.

Leptasterias fascicularis (Per.) Verrill.

Asterias fascicularis Perrier, op. cit., 1881, p. 1; Mem. Etoiles de Mer, p. 200, pl. iii, fig. 3, 1884.

The type had the radii 9^{mm} and 57^{mm}; ratio, 1—6.3. The five slender rays are slightly contracted proximally. The dorsal and dorso-lateral surfaces of the rays have about seven alternating rows of plates, separated by papular areas smaller than the plates, and containing usually two papulæ, and holding about two or three dermal minor pedicellariæ.

The plates of the median row have a curved row of three or four short, blunt spines; those of the other rows have one or two similar spines; some single spines are also situated on the interpolated ossicles.

The disk is small and covered with spines like those of the rays; between them are some oval major pedicellariæ with curved valves, touching only at tips.

On the under side of the rays there are two rows of plates, near the adambulacrals; each plate bears a single spine and often a dermal minor pedicellaria.

The adambulacral spines are rather long and slender, two to a plate, divergent, forming two regular rows.

This species seems to be a true *Leptasterias*, allied to *L. compta* of New England. Its mode of reproduction and position of genital pores are unknown, and therefore its generic position cannot be positively determined.

The type was from off Guadaloupe, in 309 fathoms.

LEPTASTERIAS HARTII R. Rathbun.

Leptasterias hartii R. Rathbun, Echinoderms of Brazil, Trans. Conn. Acad. Science, vol. v, p. 145, 1879.

This is a small, six-rayed species. Radii of the type were about 3.2^{mm} and 19^{mm}; ratio, 1:6.

Rays are well rounded above, tapering regularly to slender tips. The row of median radial plates is distinct; each plate bears a V-shaped row of about five small spines, becoming reduced to two or three distally. Spines on the disk are similar to those on the rays, closely and irregularly arranged.

Above the first lateral radial row there are, on each side, about two longitudinal series of small spines, with many interpolated on the connective ossicles. The rows are not very regular. The first lateral row, probably superomarginals, has two small spines to a plate, distinct to tip of rays; the series above this has, on each plate, transverse, irregular groups of four or five spines, decreasing to a single one distally.

On the under side there are about three rows of plates and spines. The inferomarginal row has usually one spine, seldom two, to a plate.

The two marginal rows are well separated.

The spines of the interactinal plates form oblique series of two or three. They are larger than the adambulacrals, but not much longer, and have compressed clavate tips.

The adambulacral spines are regularly two to a plate, slender and clavate proximally; distal ones tapering; outer ones a little larger.

Major pedicellariæ are large and numerous, variable in size, generally scattered, above and below. They are triangular or ovate in form, with a strongly curved basal piece; about two-thirds as broad as long. The larger ones equal or exceed in length the lateral and dorsal spines, and are much stouter. They

are most numerous between the lateral and ventral spines. The papulæ are mostly isolated.

Taken from a telegraph cable, about 30 miles east of Cape Negro, Brazil, in 62 fathoms.

The description above is condensed from that of Mr. Rathbun.

LEPTASTERIAS MEXICANA (Lütk.) Verrill.

Asteracanthion mexicanum Lütken, Vidensk. Meddel., p. 94, 1859.
Asterias mexicana Verrill, op. cit., p. 344, 1867.

This was described by Lütken from two small specimens from Vera Cruz. They were evidently young. The larger was 1.5 inches in diameter. I am not aware that anyone has obtained additional specimens.

According to Lütken the rays are five; the upper side has about seven rows of short, obtuse, rough spines surrounded by a dense basal wreath of minor pedicellariæ. The papulæ stand two or three together.

The adambulacral plates are one and two to a plate, in pretty regular alternation. They bear pedicellariæ at about midheight. They are slightly flattened, slender, and obtuse. The ventral side has two rows of small spines. (Condensed from Lütken.)

Lütken compared it to *L. mülleri*, the type of *Leptasterias*. Although it appears to have the external characteristics of *Leptasterias*, it may be the young of a larger species of *Asterias*, like *A. forbesi*.

There is no reason why *A. forbesi* should not be carried to Vera Cruz adherent to the bottoms of vessels from our southern ports, even if it does not habitually live on the Mexican coast. Many other creatures are thus carried to distant places and no doubt, in many cases, become naturalized in new homes by this means. I have not seen *A. forbesi* from the Gulf of Mexico, but should expect to find it on the coast of West Florida and Alabama.

Genus STEPHANASTERIAS Verrill, 1871. Type, *S. albula*.

Stephanasterias Verrill, Bull. Essex Inst., iii, p. 5, 1871; Expl. of Casco Bay, Proc. Am. Assoc. Adv. Sci. for 1873, pp. 356, 359, 364, 1874; Check List Invert., 1879; Expl. Albatross, 1883, p. 540, 1885.

Nanaster Perrier, Exp. Trav. et Talism., pp. 129, 131, 133, 1894; Camp. Scientif. l'Hirondelle, p. 27, 1896. (Type, *S. albula.*)

Stichaster (*pars*) Verrill, 1866, p. 351. Perrier, p. 347, 1875. Sladen, p. 432, 1889.

Stephanasterias Verrill, Revision Genera and Species of Starfishes, p. 222, 1899; North Pacific Starfishes, op. cit., p. 146, 1814a.

Small autotomous starfishes, commonly found with five to nine unequal rays, due to incomplete replacement and regulation of rays after division. Two or three longer rays, and three or four shorter ones are common forms. When fully mature, often regularly six-rayed.

The whole surface is thickly covered with minute thorny spinules, placed in clusters on the plates, and longer on the under side and margin.

The median-radial and marginal rows of plates are usually distinct, with wide plates, closely imbricated radially. The several dorsolateral rows have the plates small, short, and relatively wide, irregularly arranged, but with longitudinal rows of papular pores between them.

The inferomarginal and interactinal plates form regular, close, longitudinal rows.

The adambulacral spines are slender, two to a plate, or alternately one and two. Papulæ are isolated or in small groups. Both kinds of pedicellariæ are present.

Perrier changed the name of this genus to *Nanaster*, because he erroneously assumed that *Stephanasterias* had been preoccupied by *Stephanaster* Ayres. The two names are distinct and differently derived.

Stephanasterias gracilis (Per.) Verrill.

Asterias gracilis Perrier, op. cit., p. 4, 1881; Nouv. Arch. du Mus., vi, p. 204, 1884.

Stephanasterias gracilis Verrill, Trans. Conn. Acad. Sci., vol. x, p. 223, 1879; Starfishes N. Pacific, p. 146, 1914a.

Plate ix; figures 2-2*c*.

Disk small; rays slender, variable in number, commonly six. The species is autotomous, and the rays are often unequal.

The dorsal surface is closely covered with numerous nearly uniform minute, slender, subdiaphanous spinules, several on each plate. The marginal spines are larger, flattened and enlarged distally, mostly with a blunt and thorny tip, and more or less hyaline.

The adambulacral spines are two to a plate, shorter and much

more slender than the marginals, slightly clavate, subhyaline; oral and adoral spines similar.

This closely resembles *S. albula*, of the northern coast and arctic regions. It seems less variable in number of rays and is perhaps less often divided by autotomy. Its marginal spines are longer, more expanded and flatter.

I have examined several of the types of this species in the Museum of Comp. Zoölogy, from the Blake Expedition, described by Perrier.

It was taken by the Blake at nine stations in 56 to 183 fathoms, among the Lesser Antilles, and at two stations in the Gulf of Mexico, off West Florida, in 95 and 101 fathoms. The Albatross also took it at many stations.

It was obtained by the Bahama Expedition, off Havana, in 110 and 200 fathoms (stations 4 and 13), and off East Florida, in 110 fathoms (station 64, 6 specimens).

STEPHANASTERIAS HEBES Verrill, sp. nov.

Plate ix; figure 3.

General appearance and size much as in *S. albula*, but stouter with less numerous and less delicate spines.

The adambulacral spines form two perfectly regular divergent rows. They are relatively short and not very slender, terete or slightly clavate and blunt. The ambulacral furrow is relatively very wide and the sucker feet large. Owing to the shortness of the spines and width of the groove, the adambulacral spines cover only a small part of its margins.

The interactinal and inferomarginal spines are much larger and stouter than the adambulacrals and much more so that in *S. albula*. They are about twice longer and more than twice thicker than the adambulacrals adjacent. They are clavate, with rounded or obtuse tips, not so thorny as in *S. albula*, nor so translucent. The dorsal spines are similar, but shorter, arranged in close clusters on the plates.

Taken by the Albatross at station 2766, in — fathoms. (No. 18,426, Nat. Mus.)

This is very much stouter than *S. gracilis*, with much larger and more clavate spines.

Family ZOROASTERIDÆ Sladen.

Zoroasteridæ Sladen, op. cit., pp. xxxvi, 416, 1889. Perrier, Exped. Trav. et Talisman, p. 112, 1894. Ludwig, op. cit., 1905, p. 159.

Disk small; rays long and slender, angular or rounded.

The disk is covered largely by the ten enlarged basal radials and interradials, and the large central plate.

A row of large overlapping carinal plates stiffens the rays, each usually bearing a spine. Marginal plates scarcely differentiated from the dorso-laterals and interactinals.

All these form close, regular, imbricated, longitudinal rows, often six to eight proximally. They are also imbricated in transverse rows.

All the plates are granulated or finely spinulose and the lateral and interactinal rows usually bear, also, a single elongated spine, and usually a dermal major pedicellaria. Papular pores are single and placed between all the rows of plates.

Adambulacral plates are alternately unlike. The larger are compressed, carinate, and project far into the groove. They bear a divergent row of several spines transverse to the groove, and have one or two small spines in the groove. The alternate small plates do not project into the groove, are not carinate, and bear fewer spines. Spines of both kinds of plates may bear large major pedicellariæ.

Minor or crossed pedicellariæ appear to be lacking. Sucker-feet are in four rows proximally, becoming reduced to two rows distally. Their suckers are small.

This is essentially a deep-sea family. Only a few species have occurred in less than 150 fathoms.

Genus ZOROASTER Thomson.

Zoroaster W. Thomson, Depths of the Sea, p. 154, 1873. Sladen, op. cit., p. 416, 1889. Perrier, op. cit., 1894, p. 115. Fisher, op. cit., 1911*b*, p.

The central plate of the disk has few smaller plates around it. The basal radials are prominent, but not much larger than the next radials and of the same character. The basal interradials are smaller and flatter, without a central spine. The central plate and basal and median radials have a central short articulated spine. The whole surface is covered with a rather thick dermis and with small articulated spinules, attached to basal papillæ.

In addition to these the lateral and interactinal plates have one slender, articulated spine.

The dorso-lateral row of plates next the carinal row is differentiated, the plates being larger than the others and similar to the carinals. The rest of the lateral and interactinal plates are all similar, forming six to eight regular rows, imbricated both longitudinally and transversely, leaving only small papular pores between them. Marginals are not much different from the rest.

Adambulacral plates of two sorts are very unlike. The larger carry four to six divergent slender spines, along the thin carinate edge; the larger one at the margin of the groove may bear one or several major pedicellariæ, often large; other spines may bear smaller ones. The much smaller alternate plates are not carinate and bear usually two slender outer spines and a small one in the furrow. Major pedicellariæ are scattered on the back and sides.

Zoroaster ackleyi Perrier.

Zoroaster ackleyi Perrier, Comptes rendus, 1880, p. 436; op. cit., p. 6, 1881; Etoiles de Mer, p. 197, pl. iii, fig. 1, 1884; Exped. Trav. et Talisman, p. 117, 1894. A. Agassiz, Three Cruises of the Blake, vol. ii, p. 105, fig. 382.

The largest specimen examined by me has the radii 10^{mm} and 105^{mm}; ratio, 1:10.5; diameter of rays at base 10^{mm}; height 11^{mm}.

The small disk is convex or a little swollen. The long slender rays are well rounded at the base, but become somewhat carinate on the attenuated distal half.

The disk is occupied largely by the ten basal radial and interradial plates, and a large prominent central plate, with a central mamilla supporting a short obtuse spine.

The dorsal radials are larger and more elevated than the interradials and have a central boss, which bears a short obtuse spine. They are rounded with small notches or emarginations around the margin, where there are isolated papular pores. Similar pores surround the central plate.

The basal interradials are flatter and more angular and have no central spine. They are in contact with the radials laterally. One of them is partly covered by the madreporic plate, which is rather large and convex, with radiating gyri.

The central plate of the disk is surrounded by several small plates, and by papular pores.

All the plates of the disk and dorsal side of the rays are thickly covered with minute rough spinules that leave little round scars when rubbed off.

Pedicellariæ of the forficulate kind, much larger than the spinules, are scattered over the whole surface, usually but one to a plate. When closed they are ovate-lanceolate, and somewhat compressed, subacute.

The median radial row of plates is conspicuous. They are rather large, convex, with a small central boss, carrying a small short, thick spine, which is somewhat enlarged or obtuse at tip; the distal ones are smaller and acorn-shaped. They are easily detached and are often rubbed off. They are often absent from the distal part of the rays. These radial plates are shield-shaped, with rounded sides and overlap each other serially.

The sides and lower surfaces of the rays are proximally made up of seven to nine regular rows of small shield-shaped plates, all much alike, except the first row, so that it is not easy to distinguish the marginal rows. The row next the median radials has larger, angular plates, similar to the median, though smaller. The others are imbricated transversely, in regular vertical rows, decreasing in size downward, and overlapping with their angular lower end, like slates on a roof.

In five or six lower rows each plate bears on a boss, a long, slender, very acute spine, decreasing upward in length, where they nearly intergrade with the spinules of the upper plates. These spines are also accompanied by small, acute spinules, and each plate usually has a rather large lanceolate or acute-ovate pedicellaria. Distally a similar spine appears also on the row next to the carinal row.

The adambulacral plates are alternately large and small. The larger ones are carinated and project far into the groove and bear, on the curved edge, five or six slender acute spines, of which two or three are within the groove, one far within, and the others form a divergent row, transverse to the furrow, the middle or marginal ones longest. Many of these spines, both within and outside the furrow, bear a single large, forficulate or major pedicellaria, some of them much thicker and about as long

as the spine, and much larger than those of the dorsal surface. Some spines have also two or more smaller ones. The larger ones, on the marginal spine, are compressed, long ovate, with acuminate or contracted tips; the smaller ones are acute-ovate, like the dorsal ones. The largest occur on the outer dorsal spines.

The peroral and adoral spines are considerably elongated and acute. The oral area is deeply concave, so as to conceal most of the spines. The smaller alternate adambulacral plates are not carinate and do not project into the grooves. They usually bear one very small inner spine and two longer very unequal outer ones.

The ambulacral sucker-feet are large. Proximally they form four rows; farther out they are in two zigzag rows on each side; toward the end of the rays, they are reduced to two nearly straight rows.

This was taken by the Blake, at station 134, off Santa Cruz, in 248 fathoms, 10 specimens; and at station 157, off Montserrat, in 120 fathoms, one specimen.

The specimens studied by me were mostly taken by the Albatross. The larger, described above, was from station 2396, off Pensacola, Fla., in 335 fathoms, gray mud, bottom temperature 41.80° F. (No. 18,450, Nat. Mus.) The other was from station 2394, also off Pensacola, in 525 fathoms, light gray mud (No. 10,422). It was also taken at several other localities.

Family Pedicellasteridæ Perrier.

Pedicellasteridæ Perrier, Etoiles de Mer., pp. 167, 194, 1884; Exped. Trav. et Talism., p. 92, 1894. Sladen, op. cit., p. 556, 1889. Verrill, op. cit., p. 202, 1914a.

Pedicellasteridæ (*pars*) Perrier, op. cit., 1885, p. 15.

Disk small, rays usually five or six, sometimes ten to twelve or more, as in *Coronaster*. Dorsal skeleton usually reticulated, or with few rows of plates.

Ambulacral feet are in two rows, at least distally. The jaws are formed by modified adambulacral plates. Pedicellariæ are of two kinds, much like those of Asteriidæ.

Genus Coronaster Perrier.

Coronaster Perrier, Ann. Sci. Nat. Zoöl., vol. xix, No. 8, pp. 5, 9, 1885; Exped. Trav. et Talism., p. 92, 1894. (Type, *C. parfaiti.*) Sladen, op. cit., pp. xxxix, 592, 1889.

Delicate starfishes with a small disk and numerous slender rays, covered with long, slender spines in radial rows. The dorsal skeleton is weak, made up of the rows of median and superomarginal plates, connected together by slender transverse ossicles. Each plate of the longitudinal rows usually bears one slender spine.

Both rows of marginal plates well developed and spiniferous. No interactinal plates. Adambulacrals diplacanthid. Large, felipedal, dermal major pedicellariæ occur above and below. Minor pedicellariæ form large circumspinal wreaths, borne on contractile sheaths. Tube-feet are relatively large, in two rows, not crowded. A pair of rather large peroral spines on the margins of the oblong jaws, with groups of oral marginal pedicellariæ.

Coronaster briareus Verrill, 1914*a*, p. 49.

Asterias briareus Verrill, Brief Cont. to Zoöl., No. 50, Amer. Journal Sci., vol. xxiii, p. 220, 1882; Notice of Rem. Maine Fauna, in Annual Rep. Com'r. of Fish and Fisheries for 1882, p. 659, 1884, ditto for 1883, p. 540; Amer. Jour. Science, ser. 3, vol. xlix, p. 209, 1895.
Starfish "*near Asterias volsellata,*" Nutting, Narrative Bahama Exped., p. 168, fig. 3, 1895.

Plate i; figures 1, 2. Plate ix, figures 4—4*c*.

Disk small,rays slender, elongated. Rays variable in number, ten to twelve in the larger specimens, one of the larger has the radii 8^{mm} and 76^{mm}; ratio 1:9.5.

The dorsal skeleton is openly reticulated. There is a marked medial radial carina, with larger plates and longer spines. The marginal plates also form ridges. These five rows of plates are connected by slender transverse ossicles, leaving large rectangular papular areas, with numerous papulæ in clusters.

The dorsal and marginal spines are long, slender, acute, not very near together. A few arise, also, from the transverse ossicles.

The spines are all much alike in form and size. They bear large dense wreaths of small minor pedicellariæ, usually on a

sheath which may be contracted to near the base or extended to near the tip in preserved specimens.

Solitary felipedal or unguiculate major pedicellariæ of large size and remarkable in form are scattered on the dermis, above and below; others are on the inner furrow margins. They are hand-shaped, with curved, acute terminal denticles, interlocking like fingers or claws. The valves are wider distally and there are generally about five or six interlocking denticles.

The adambulacral spines are two to each plate, slender, elongated. There are no interactinal plates nor spines; the inferomarginals join closely to the adambulacrals.

It was taken by the Bahama Expedition at Station 61, off Key West, in 75 to 80 fathoms, and at Station 64, in 110 fathoms, off American Shoal, Florida.

It was dredged by the U. S. Fish Commission, at several stations in 31 to 373 fathoms, between N. lat. 37° 18′ 11″ and 36° 41′ 05″.

This is the species described by Professor Nutting, as the most beautiful starfish obtained. See Narrative of Bahama Expedition, p. 168, and figure on opposite plate.

Genus Pedicellaster Sars.

Pedicellaster Sars, Oversigt Norges Ech., p. 77, 1861. Perrier, op. cit., 1884, p. 194; Exped. Trav. et Talism., p. 99, 1894. Sladen, op. cit., p. 557, 1889. Verrill, op. cit., p. 202, 1914a.

Delicate starfishes with a small disk and usually five or six slender rays, sometimes more. Dorsal plates form a reticulation. Ambulacral feet in two rows. Ambulacral groove relatively wide and open. Dorsal and marginal plates are covered with small spinules.

Pedicellariæ of both kinds are formed on most, if not all, species when adult.

Pedicellaster pourtalesi Perrier.

Pedicellaster pourtalesi Perrier, Bull. Mus. Comp. Zoöl., vol. ix. p. 7, 1881; Etoiles de Mer, p. 194, pl. iii, fig. 4.

Rays very slender, fragile at base, elongated, terete, obtuse. The type had the radii 4^{mm} and 21^{mm}; ratio, about 1:5.

Dorsal plates are delicate mostly in three rows, a carinal and

one dorsolateral on each side, united transversely by small ossicles. Each principal plate bears a single small spine, marginal plates and spines are similar.

The adambulacral plates are relatively large; each bears two or three small, slender spines in a transverse row.

The madreporic plate is small, with few gyri. Minor pedicellariæ are dermal, scattered between the dorsal spines.

Recorded by Perrier from four Blake stations, among the Lesser Antilles, in 127 to 250 fathoms. It was also taken by the Albatross in the same region.

Order Spinulosa Perrier.

Stelleridæ Spinulosæ Perrier, Nouv. Arch. Mus. Hist. Nat., vi, p. 154, 1884.
Spinulosa Perrier, Exped. Trav. et Talism., pp. 27, 138, 1894.
Phanerozonia and *Cryptozonia* (*pars*) Sladen, Voy. Chall., xxx, p. xxiii, 1889.
Spinulosa Fisher, op. cit., 1911b, p. 251. (Table of known families.) Verrill, op. cit., pp. 24, 304, 1914a.

This order, established by Perrier, includes cryptozonate (rarely subphanerozonate) starfishes, which usually have but two rows of ambulacral feet (four in *Diplopteraster*). The ambulacral plates are not crowded. The dorsal plates, generally reticulated or imbricated, spinulose, granulose or naked, often form pseudopaxillæ or parapaxillæ, but they rarely, if ever, form true paxillæ. The dorsal plates are sometimes isolated, rudimentary, or absent in deep-sea genera. The pedicellariæ are commonly lacking; when present they are neither forcipulate nor forficulate. They may be pincer-like, with two or more simple valves, and are always dermal.

Perhaps the structure of the pedicellariæ is the most positive character for separating certain genera of this group from some of the aberrant Forcipulosa.

The marginal plates are nearly always small and sometimes indistinct; the lower ones are usually the larger; they never form a thick rigid margin; the margin may be acute or rounded. Papulæ may occur both on the dorsal and on the actinal surfaces, but they are restricted to the dorsal surface in most families. The odontophores are adambulacral and of various forms. The ambulacral grooves are usually narrow. The ambulacral feet always have a terminal sucker. The ambulacral ampullæ may be single (Echinasteridæ) or double.

A number of the genera do not have free-swimming larvæ,* but are known to carry their eggs and larvæ attached about the mouth, or else in a marsupial pouch (*gonocodium*) until they become true starfishes, large enough to care for themselves. This habit is usually associated with the lack of pedicellariæ. It is conducive to the formation of local varieties. The order may be naturally divided into two suborders:

Suborder I — Avelata Ver., op. cit., 1913; 1914*a*, p. 204.*

This includes the more typical forms in which there is no dorsal, tent-like marsupial chamber for the protection of the eggs and young. The spines are either all free, or partially or wholly webbed together into groups, as in *Solasteridæ*, in which the groups of adambulacral spines form transverse combs completely webbed together, and the dorsal spinules are partially so.

It includes the following families represented in this collection: *Echinasteridæ; Solasteridæ; Korethrasteridæ*, deep sea; *Asterinidæ; Poraniidæ.* Also the following extralimital families, besides other smaller groups: *Acanthasteridæ; Mithrodidæ; Pythonasteridæ*, deep sea; *Myxasteridæ*, deep sea.

II — Suborder Velata Perrier (as an order).

This group includes only the family *Pterasteridæ.* It is remarkable for having most of the spines webbed together in clusters and for the remarkable development of a superdorsal membrane, more or less completely uniting the paxillæ together, and usually forming a dorsal marsupial pouch or gonocodium in which the eggs and young are carried.

Suborder Avelata Verrill (See above).

Family Echinasteridæ Verrill (restricted).

Echinasteridæ Verrill (*pars*), Trans. Conn. Acad. Sci., i, p. 343, 1867. Perrier (*pars*), Revis. Stell., Arch. Zoöl., iv, pp. 299, 358, 1875.

Echinasterinæ Viguier, Arch. Zoöl. Exper. et Gen., vii, p. 123, 1878 (structure.)

Echinasteridæ Sladen (*pars*), Voy. Chall., xxx, p. 535, 1889. Bell, Catal. Echinod., pp. 23, 95, 1890. Perrier, Etoiles de Mer, Nouv. Arch. Mus. Nat. Hist., vi, p. 164, 1884; Exp. Trav. et Talism., pp. 28, 141,.

* This is the case with the genera *Henricia, Pteraster, Hymenaster*, and others.

* There once misspelled as *Alvelata.*

1894. Ludwig, Fauna Arctica, i, p. 472, 1900. Fisher, op. cit., 1911*b*, p. 258, analytical table known genera, p. 259. Verrill, op. cit., p. 205, 1814*a*.

Dorsal skeleton usually formed of small, sometimes overlapping, reticulated or areolated plates; sometimes they form longitudinal radial rows. Median dorsal row is often indistinct. Upper marginals small, often not specialized. Inferomarginals usually distinct. One or more interactinal rows are usually present. Dorsal and marginal spines may be large and isolated or minute and clustered, but not truly paxilliform. They are often covered with a distinct, thick, dermal membrane, which may contain calcareous granules.

The ambulacral ampullæ are usually single, one to each tubefoot.

Ambulacral grooves narrow. Adambulacral spines small, two or several to a plate, usually in a transverse group or a single transverse row. No pedicellariæ are known.

The most prominent genera are *Echinaster* and *Henricia*, both of which occur in the West Indies.

Genus ECHINASTER Müller and Troschel, emended.

Echinaster (*pars*) Müller and Troschel, Monatsber., Berlin. Wis. Akad., April, 1840, p. 102; Wieg. Arch., 1840 (*non* Gray); Syst. Aster., p. 22, 1842 (*pars*).

Othilia Gray, Ann. Mag. Nat. Hist., vi, p. 281, Dec., 1840; Synopsis Starfishes, p. 12, 1866. Fisher, 1911*b*, p. 260.

Echinaster Perrier, Revis. Stell. du Mus., Arch. Zoöl. Exper., iv, p. 364, 1875. A. Agassiz, North Amer. Starfishes, p. 97, pl. x, 1877 (structure of skeleton.) Viguier, Squelette Stell., Arch. Zoöl. Exper., vii, p. 123, pl. vii, figs. 1-7, 1878 (structure of skeleton.) Sladen, Voy. Chall., Zoöl., xxx, p. 553, 1889. Perrier, Exp. Trav. et Talism., p. 146, 1894. Verrill, op. cit., p. 206, 1914*a*.

Stellate, usually with the disk rather small. Rays normally five, of moderate length, rounded. Larger dorsal and marginal plates strong, lobate, convex in the middle, and having a central mammilla and pit for the attachment of the usually solitary spine. The larger ossicles are united into reticulations by small, rounded, connective ossicles, leaving large papular areas; solitary papulæ may occur in the marginal and actinal regions.

The whole surface is covered in life with a rather thick, soft integument, containing small granules on the spines. Dorsal

spines are conical, acute, mostly isolated, sometimes in small groups.

Upper and lower marginal plates are not very distinct, with spines like the dorsals. Adambulacral spines form a small oblique or transverse row of two to four; the inner ones are smaller, inserted in the groove, just above the margin.

The genus *Othilia* Gray, December, 1840, appears to be a synonym of *Echinaster* Müller and Troschel, April, 1840. The type of the latter was *E. spinosus* [8] = *A. echinophora* Lam., both by virtual tautology and by designation. (See foot-note in Müller and Troschel, Syst. Ast., p. 22, 1842.) *Echinaster* of Gray, 1866, is *Acanthaster* of later writers.

This genus is found in all tropical and subtropical seas, chiefly in shallow water.

ECHINASTER SENTUS (Say) Lütken.

Asterias sentus Say, Journ. Philad. Acad., v, p. 143, 1825.

Othilia aculeata Gray, Annals Nat. Hist., vi, p. 281, 1840; Gray, Synopsis Starfish, p. 12, 1866.

Echinaster spinosus (*pars*) Müller and Trosch., Syst. Ast., p. 22, 1842. Verrill, Notes on Radiata, p. 343, 1867. Ives, Proc. Acad. Nat. Sci. Philad., for 1890, p. 325. Clark, Echinoids and Asteroids of Jamaica, p. 6, 1898.

Othilia spinosa Agassiz, Bull. Mus. Comp. Zoöl., p. 308, 1869.

Echinaster sentus (Verrill, MSS., 1866). Lütken, Vid. Meddel., pp. 60, [284], 1871; [9] Perrier, Arch. Zoöl. Exper., iv, p. 366, 1875; A. Agassiz. North American Starfishes, p. 97, pl. x, figs. 1-6, 1877 (figs. of living and structure.) R. Rathbun, Echinoderms of Brazil, p. 147, 1879.

Plate xxix; figure 2. Young.

The two marginal rows of plates are pretty regular but not much differentiated from the others in size or form. The upper row usually has only one stout conical spine, with a mammiform base, on each plate. It turns upward proximally, reaching the dorsal side, and leaving a wide interradial intermarginal area, in which there are a number of spineless plates, and usually one short intermarginal row of plates bearing one spine each in a typical specimen from Florida.

[8] The name *spinosus* (Retz.) is not tenable for any species of the genus for *Asterias spinosa* R. was antedated by *A. spinosa* Pennant, 1777.

[9] Lütken here refers to Verrill (correspondence) and to his determination in 1866 (op. cit., p. 348), of *sentus*.

The intermarginal plates are like the upper ones, but extend regularly to near the small adoral area. Some of them sometimes bear two, or even three, conical spines, close together, but ordinarily only one. The peractinal plates form a single row of small, oblong, transverse connective ossicles between the inferomarginals and the adambulacrals. Between them are large papular pores, either isolated or in small groups; many of these ossicles are without spines, but some of them usually have a small conical spine, near the outer adambulacrals.

The adambulacral spines are small and subacute, in somewhat oblique transverse series of three. They are much smaller and more numerous than the adjacent spines, about four of their plates corresponding to one marginal plate. The inner furrow-spine is much the smaller; the next is nearly as large as the outer one. These last are webbed together basally and thus form a continuous regular border to the furrow. Most of the dorsal spines can be referred to five irregular rows, above the superomarginals. These are one pretty distinct median radial row, and two less distinct dorso-lateral rows on each side. There are also some irregular interpolated spines on the connective ossicles. Many of the larger plates bear two and some three clustered spines.

The papular areas are large and the papulæ are very numerous, not only on the dorsal side, but also between the marginal rows, and are present also next to the adambulacrals, where they become less numerous.

The madreporic plate is raised, flat, wart-like, covered with rough projections, like stout spinules.

The Young. Plate xxix; figure 2.

A young specimen, apparently of this species, was taken by the expedition in shallow water on the Great Bahama Bank. Its radii are 7^{mm} and 26^{mm}. It has the two rows of marginal spines well developed and pretty regular. There are about eight or nine in the upper series and about twelve in the lower. They are relatively large, conical, acute.

The dorsal spines are similar in size and form. They form, on some of the rays, too pretty definite dorso-lateral rows of five or six, with a few in the median row. In other cases the median

row has five or six spines and the doso-lateral ones fewer. The papular pores are small and numerous dorsally; few and mostly isolated below the inferomarginal spines. A row of small interactinal plates separates the inferomarginal plates from the adambulacrals and some of these bear rudimentary spines, and many have small solitary papulæ between them.

The adambulacral plates have three small spines in an oblique row; the inner one is very small and deep in the furrow; the outer ones are webbed together longitudinally. Color, when dry, pale yellowish brown. The madreporite is small, round, rough with minute spinules.

Teratology.

A regular four-rayed specimen was obtained by the Bahama Expedition at the Great Bahama Bank, in shallow water, May 17, 1893.

The radii are 13^{mm} and 53^{mm}; ratio, 1:4.1. The dorsal spines are rather numerous, subequal, of moderate size and acute. They do not form definite or obvious rows, but appear as if in about six or seven zigzag and irregular rows proximally. They are not crowded.

Papular areas, between them, are large, with many rather large pores; these areas form about six irregular rows. Additional ones exist between the rows of marginal spines and scattered papulæ occur between the inferomarginals and the adambulacrals, and between the interactinals.

The rows of superomarginal spines are not clearly distinct from the dorsals, being of the same size and form and the rows are irregular. The inferomarginal row is more regular, but the spines are of the same size. This row is near the adambulacral plates and about four of the adambulacral plates correspond to each of these spines in the amount of space occupied. There are about twenty to twenty-four of these spines in each row. Proximally there is a short irregular intermarginal row, and also a row of small interactinals, the latter mostly spineless.

The adambulacral plates mostly bear three partially webbed spines. Two on the outer surface are subequal, one nearly

above the other; the other is much smaller and deeper in the groove; distally there is often another smaller furrow-spine still deeper in the groove. The madreporite is round, elevated, wart-like, and covered with small rough spinules. The color of the dry specimens is yellowish brown, to dark purplish brown.

Mr. A. Agassiz (op. cit., 1877, pl. x) gave excellent figures of this species from living specimens as well as many structural details of the skeletal parts.

It is the common shallow water species found on our coast, from North Carolina to Florida. In the number and size of the spines and the number of the rows it exceeds *E. echinophora*, but has many less than *E. spinulosa.*

Most of the earlier writers, including Lamarck, Müller and Troschel, and many others combined this with *E. echinophora*, under the specific name "*spinosus*," a name that was often attributed to Retzius, 1805 (as *Asterias spinosa*), which was antedated, however, by *A. spinosa* Pennant. It is doubtful, as shown by Lütken, whether the brief diagnosis of Retzius refers to any *Echinaster*. In any case it was preoccupied and cannot be used for any species of this genus.

The *Asterias spinosa* of Say, 1825, was primarily the common *Asterias forbesi* of our coast, but also included *A. vulgaris*, for he had specimens from the coast of Maine.

This determination, and also the fact that Say's *A. sentus*, was an *Echinaster* like *spinosus* of authors, was published by me in 1866. (Proc. Boston Soc. Nat. Hist., vol. x, p. 348) and was earlier communicated to Lütken. I did not publish the combined names at that time.

This species occurs in shallow water on the southern coasts of the United States, from North Carolina to the Florida Reefs, and to Yucatan. It is also common in the West Indies, from the Bahamas to St. Thomas. I have seen it from Cuba, Bahamas, and Hayti. Yucatan (Ives), St. Thomas (Lütken), Bahia and Pernambuco, Brazil (R. Rathbun), Jamaica (Clark).

The Bahama Expedition took specimens on the Great Bahama Bank, including one four-rayed specimen, described above.

ECHINASTER SPINULOSUS Verrill.

Echinaster spinulosus Verrill, Proc. Boston Soc. Nat. History, vol. xii, p. 386, 1869. Lütken, op. cit., p. 285 [61], 1871. Ives, op. cit., p. 326, 1890.

Plate iv; figures 1, 2.

This species is characterized by having long, slender, terete, tapered rays, covered with numerous small, conical, subacute or often blunt spinules, in many more or less evident rows, and often standing two or three on a plate. The number in each row may be forty or more.

The number of rows, exclusive of inferomarginals, may be from fifteen to twenty-one in the larger examples. A medium-sized specimen (type) has the radii 12^{mm} and 72^{mm}; ratio, 1:6. The largest specimens have the radii about 14^{mm} and 80^{mm}.

A typical specimen of medium size from West Florida has these characters; the two rows of marginal plates can readily be distinguished in this and in most other dried specimens, not only by their larger size and more rounded form, but also by a finely granulated and well defined patch on the convex part of each plate and mostly below the single spine, but often including most of the surface of the plate. Over this granular surface the investing dermal membrane is so thin that the granules can usually be seen without preparation, and sometimes they appear as if naked. They are not found on the intermarginal and peractinal plates.

The two rows of marginals are pretty regular and can be traced to the tips of the arms, each bearing one small conical spine. On the distal third of the ray the two rows are contiguous; on the proximal part they are separated by two or three short, irregular rows of intermarginals, each bearing a conical spine. In the interradial area additional spineless plates are interpolated, broadening the area, for here the upper marginal row turns upward to the dorsal side.

Many papular pores are found between the marginals and intermarginals, but none below the inferomarginals in most specimens.

Granulated patches also occur on the plates of the principal dorsal rows.

The interactinal or peractinal plates and spines form a pretty regular row, extending nearly to the tips of the rays,

where they become very small. Most of them bear one small conical spine, close to the outer adambulacral. The outlines and sutures of these plates are usually concealed by dermis; sometimes proximally, a number of them are spineless and visible, when they appear as narrow, flat, oblong, transverse ossicles, extending between the inferomarginal and adambulacral plates. The adambulacral plates have two small furrow-spines, one above the other. The most interior one is the smaller; on the outer margin, and not quite in line with the others, there is a somewhat larger and stouter but small, conical spine. Those on consecutive plates are webbed together for about half their height and also webbed to the upper one of the furrow-series, forming a continuous row.

The madreporic plate is prominent, flattish, wart-like, covered with thin, rough, irregular ridges and points.

Alcoholic and well dried specimens of this species are usually purplish brown, but many, when dried, become yellowish brown. In life it is reddish brown.

This species is abundant on the west coast of Florida, at Tampa Bay, Egmont Key, and many other localities.

In the Yale Museum, besides the types from Egmont Key, there are specimens received from the U. S. Nat. Mus. from the following places: Pine Key, Cedar Key, Goodland Point, and Marco, W. Florida; Gulf of Mexico, S. of Alabama (stations 2370, 2373, 2387, steamer Albatross), in 23 to 32 fathoms. I have seen no West Indian specimens nor any from East Florida.

This is more nearly allied to *E. braziliensis* than to either of the other species.

It has many more rows of spines than *E. sentus*, and many more spines in each row, while the spines are also much smaller and more slender. The rays are also longer and more slender.

ECHINASTER BRAZILIENSIS M. and Tr.

Echinaster braziliensis M. and Trosch. (pars), Syst. Aster., p. 22 (not the figure, pl. i, fig. 4). Lütken, op. cit., p. 9 [67], 1859; p. 284 [60], 1871. Verrill, Notes on Radiata, pp. 343, 368, 1868. Perrier, Archiv. Zoöl. Exp., vol. iv, p. 367, 1875. R. Rathbun, Trans. Conn. Acad Sci., vol. v, p. 148, 1879. Ludwig, Mem. Cour. Acad. Roy. Belg., xliv, p. 7, 1882. Ives Proc. Acad. Nat. Sci. Philad., for 1890, pp. 324, 326, pl. viii, figs. 16-18, 1890.

(?) *Othilia braziliensis* A. Agassiz, Bull. Mus. Comp. Zoöl., vol. i, p. 308, 1869 (Florida, shore to six fathoms.)

Plate xxvi; figure 1.

The ratios of the radii are about 1:5. The rays are terete and rather slender. The spines are numerous, small, acute-conical, not much larger than the outer adambulacrals. On the rays they form about nine to eleven rows in the adult, with thirty or forty in the median row, in specimens 112^{mm} in diameter. The adambulacral plates have three spines.

The spines are larger and fewer than in *E. spinulosus*, but much more numerous and smaller than in *E. sentus*.

Color in life rust-red, paler below. (Ives.)

The figure of a portion of a ray given by Müller and Troschel does not agree with their description. It probably represents *E. sentus*.

This Brazilian species has been recorded from shallow water on the Florida coast by Mr. A. Agassiz; from Jamaica, by Lütken and Verrill; and from Yucatan by Ives. On the Brazilian coast it has been recorded from Pernambuco (Rathbun) to Rio de Janeiro (Perrier). The Yale Museum has it from Bahia and Pernambuco (coll. C. F. Hartt, Nos. 5206, 5208, 4559). Also a specimen, perhaps of this species, from Cuba (No. 263). Mr. Rathbun doubts the Rio de Janeiro record. Some of the other records are also doubtful, owing to confusion with allied species. That of Florida is doubtful. I have seen no specimens from Florida nor from the Bahamas.

Echinaster echinophorus (Lam.) Perrier.

Asterias spinosa (*pars ?*) Retzius, Dissert. sist. spec. cog. Asteriarum, p. 18, 1805 (*non Asterias spinosa* Pennant 1777).

Asterias echinophora Lam., Anim. sans vert., ed. I, vol. ii, p. 560, 1816.

Othilia spinosa Gray, Ann. and Mag. Nat. Hist., vi, p. 281, Dec., 1840; Synopsis Starfishes, p. 12, 1866.

Echinaster spinus Müll. and Trosch. (*pars*), Syst. Ast., p. 22, 1842; Lütken, Vidensk. Meddel., p. 90, 1859. Perrier, Pédicell., p. 57, 1869.

Echinaster (*Othilia*) *crassipina* Verrill, Trans. Conn. Acad., i, p. 368, pl. iv, fig. 7, 1868.

Echinaster crassispinus Lütken, op. cit., p. 283 [61], 1871. Ives, op. cit., 1890, p. 326.

Echinaster echinophorus Perrier, Arch. Zöol. Exper., iv, p. 364, 1875. R. Rathbun, Echinod. Brazil, p. 147, 1879. Ives, Proc. Acad. Nat. Sci. Philad. for 1889, p. 171.

The rays are angulated and not very long; not slender. Radii of a medium sized specimen 12^{mm} and 47^{mm}; ratio about as 1:4. On the dorsal and lateral surface of the rays there are about five irregular rows of rather distant, relatively large, stout, acute, conical spines, on mammilary bosses of the principal plates, and partially covered by a thick dermis. The two outer of these rows may be reckoned as superomarginals, but they are like the others.

The inferomarginals, which are on the actinal side near the adambulacrals, but separated from them by a naked lane, form a more regular row of about fifteen, somewhat larger than the dorsals, but similar in form.

The disk bears a few spines, like the radials. Beneath, the disk is covered by a smooth, naked dermis, without spines. Papular pores are numerous in large groups on the dorsal side; fewer on the sides and beneath.

The adambulacral spines are two to a plate; the outer one is much the larger and they form a close, regular, longitudinal row, partly webbed; the inner one is much smaller, not half as long, and situated deep in the furrow. Above description is from a Brazilian specimen.

In life this species is usually bright red or crimson; it becomes dull reddish brown in alcohol, and usually dark purplish brown when carefully dried.

Not uncommon in shallow water and on reefs throughout the West Indies. It extends to the Abrolhos Reefs, Brazil, and to Yucatan. Abundant in Bay of Bahia, Pernambuco, on rocky bottoms, etc. (R. Rathbun). Yucatan (Ives).

I have not seen it from Florida, nor from the Bahamas. The Yale Museum has it from the Abrohos Reefs, Brazil (coll. C. F. Hartt, No. 1527, type of *E. crassispina*), and young specimens, apparently of this species, from Parahyba de Norte (coll. Hartt, Nos. 5209, 5210, 5211).

Echinaster modestus Perrier.

Echinaster modestus Perrier, op. cit., p. 7, 1881. Etoiles de Mer, p. 206, pl. iii, fig. 7, 1884.

The type was evidently a young specimen. Its radii were 6^{mm} and 36^{mm}; ratio, 1:6.

The dorsal surface is formed of openly reticulated plates, leaving large sunken papular areas, containing groups of three or four papulæ. The investing dermis is thick.

The dorsal, dorsolateral, and lateral spines are very small and form about nine irregular rows, with scattered spines between them. The marginals are not distinct.

Besides the nine rows there is a regular row of interactinal spines, which ceases at about midlength of the ray. The adambulacral plates have a short, thick, obtuse furrow-spine, and exterior to it, an equally larger but rather shorter spine; outside of this there may be, in the same transverse line, one or more small spines.

Taken by the Blake at two stations among the Lesser Antilles, in 120 to 123 fathoms, and in the Gulf of Mexico, off West Florida, in 101 fathoms.

This has much smaller spines than specimens of *E. spinulosus* of the same size, and the surface appears more areolated.

Thyraster serpentarius (M. and Tr.) Ives.

Echinaster serpentarius M. and Trosch., Syst. Ast., p. 24, 1842. Perrier, op. cit., vol. iv, p. 370, 1875. Lütken, op. cit., p. 285 [61], 1871.
Thyraster serpentarius Ives, op. cit., p. 329, pl. viii, figs. 19-21, 1890.

The genus *Thyraster*, established for this species by Ives (1890), is separated from *Echinaster* especially by the character of the dorsal and marginal plates, which are quadrangular, or rhombic, overlapping by their angles, and placed in regular longitudinal rows. They bear three or four small, thorny spines, in a row, on the distal edge. The adambulacral plates mostly bear a row of three or four small spines on the distal margin, with a small furrow-spinelet. The marginal plates usually have three spines on the distal edge, rather larger than those of the dorsal plates, but still quite small. Diameter of the type, 4 inches.

It is a Mexican species, recorded by Müller and Troschel, and later by Ives and others, from Vera Cruz.

Genus Henricia Gray.

Henricia Gray, Ann. Mag. Nat. Hist., vi, p. 184, November, 1840; Synopsis Starfishes, p. 5, 1866. Bell, Ann. and Mag. Nat. Hist., vi, p. 473, 1890;

Catal. British Echinod., p. 95, 1892. Fisher, 1911*b*, p. 266. Verrill, op. cit., p. 209, 1814*a*.

Cribella Forbes, Brit. Starfishes, p. 100, 1841, or December, 1840.

Echinaster (*pars*) Müller and Troschel, April, 1840; Syst. Aster., p. 22, 1842.

Cribrella Lütken, Gronl. Echinod., p. 30, 1857. Norman, Ann, and Mag. Nat. Hist., xv, p. 124, 1865. Verrill, Proc. Boston Soc. Nat. Hist., x, p. 345, 1866. Perrier, Revis. Stell. Mus., Arch. Zoöl. Exper., iv, p. 373, 1875. A. Agassiz, North Amer. Starfishes, p. 113, pl. xviii, 1877 (structure of skeleton). Viguier, Squellette des Stell., Arch. Zoöl. Exper., vii, p. 126, pl. vii, figs. 8-15, 1878 (odontophore). Sladen, Voy. Chall., xxx, p. 540, 1889. Perrier, Exp. Trav. et Talism., p. 143, 1894. Ludwig, Fauna Arctica, p. 473.

Stellate starfishes usually with five terete, slender rays; sometimes with short rays and wide disk. Sometimes with six or more rays in autotomous species.

Dorsal plates are numerous and small, united into a rather closely reticulated structure, bearing numerous papular pores, either isolated or in small groups. Dorsal spinules minute and nearly uniform, crowded in divergent clusters on the convex ossicles of the dorsal, lateral, and actinal surfaces.

The madreporic plate is inconspicuous and usually spinulose; sometimes two are present in autotomous species. There is no thick dermis over the plates.

Supermarginals are small, often indistinct, and like the dorsals. Inferomarginal plates distinct, often larger than the superomarginals, contingent with the latter distally, but often separated proximally by one, two, or more interpolated rows of marginal ossicles, varying in number and extent, and thus causing great variations in the thickness and taper of the rays. Interactinals and inferomarginals similar and closely joined, convex, and covered with small spinules; the rows are separated by papular pores, which may also occur between the interactinal and adambulacral plates.

The two rows of marginal plates, the interactinal and the adambulacrals agree nearly or quite in radial length, at least proximally, so that they form regular transverse series.

The adambulacral plates are transversely oblong. Their actinal face is covered with numerous spinules in two or more transverse rows, or in a compact group; those near the furrow margin are longer, and one to three may stand on the margin; there is one

or sometimes two furrow-spines within the groove. Pedicellariæ have not been found in any species.

The eggs and young are carried in clusters around and below the oral region until the young take on the stellate form provided with sucker-feet.

This genus differs from *Echinaster* in the absence of a thick external integument; in the covering of minute spinules; and in the nearly uniform small ossicles of the dorsal and lateral skeleton, the connective ossicles being almost indistinguishable from the primary series; and in the quadrangular form and regular arrangement of the marginal and interactinal plates.

According to the accepted rules of priority it is necessary to adopt *Henricia* instead of *Cribrella* as the name of this genus, for it has at least a month of priority. *Cribrella* of Agassiz, 1835, was a different group.

HENRICIA ANTILLARUM (Perrier). Verrill, 1914*a*, p. 210.

Cribrella antillarum Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 8, 1881; Etoiles de Mer, p. 207, pl. iii, fig. 3, 1884.

Rays, in the type, five, rather long, slender terete, regularly tapered. Radii 7^{mm} and 42^{mm}; ratio, 1:6.

Dorsal ossicles small, reticulated, leaving numerous papular areas mostly smaller than the ossicles and containing a single papula. They are covered with numerous minute, short spinules. Madreporic plate single, raised, about midway between the center and margin of the disk, and covered with minute spinules similar to those of the dorsal ossicles.

Two marginal rows of plates are well developed, rectangular, closely covered with minute spinules.

There are two or three rows of interactinal plates proximally, but only one reaches the middle of the ray. Their larger plates are quadrangular and of the same length as the marginals and adambulacrals.

The latter are transversely oblong; their actinal surface is covered with small spinules; five or six of them become abruptly larger near the furrow margin and stand in two rows, two or three in each row.

Dredged by the Albatross at station 2671, off Georgia, in 280 fathoms. (No. 18,392, N. Mus.)

Perrier recorded it from five Blake Exped. stations, in 127 to 734 fathoms, among the Lesser Antilles.

The specimen from off southern Georgia (No. 18,392) has the proximal interactinal plates transversely oblong or rectangular, and similar to the marginals in size and form.

The adambulacral spines are strongly differentiated; the three nearest the groove show a decided approach to the formation of a true marginal comb. Those next to these are about twice as long as those farther back. There is a small furrow-spine deep in the groove, and distally there may be two.

Small isolated papular pores form a row between the interactinals and marginals, and also between the former plates; a few are located proximally between the interactinals and marginals.

Henricia sexradiata (Perrier) Ver.

Cribrella sexradiata Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 8, 1881; Etoiles de Mer, p. 209, pl. iv, fig. 6, 1884.
Henricia sexradiata Verrill, N. Pacific Starfishes, p. 371, 1914*a*.

Plate xi; figure 7. Details.

Rays slender, variable in number, often unequal in size; most frequently there are six of which about three are shorter than the others, due to autotomy.

The type described by Perrier had the radii 6^{mm} and 13^{mm}; ratio, 1:2.16; others have relatively longer rays.

The dorsal surface is covered with numerous small reticulated ossicles, carrying very small spinules; the papular areas are smaller than the ossicles and mostly have a single papula. Two madreporic plates are usually present, small, granulated, one each side of a single ray.

The two rows of marginal plates are very distinct; the plates are quadrangular and covered with nearly uniform minute spinules, a little larger than those on the dorsals. There is a short row of peractinal plates of similar size and form, proximally.

The adambulacral plates are transversely oblong; they bear, near the inner margin, about five small obtuse spinules, larger than the others, and forming two longitudinal rows; two belong to the inner or marginal row; three to the outer one. The rest

of their actinal surface is covered with smaller, short, obtuse spinules, resembling granules.

Perrier recorded this species from the Blake Expedition from off West Florida,[10] in 101 fathoms, and off Barbados in 150 fathoms. I have seen it, also, from Blake station 297, in 123 fathoms, off Barbados. The Bahama Expedition dredged it off Havana, in about 200 fathoms.

This may be only a variety or form of *H. antillarum.* Such differences as have been noticed may be due to the variations caused by autotomous division. The possession of six rays cannot be regarded as a specific character, especially in autotomous species.

HENRICIA MICROSPINA Verrill, sp. nov.

A small species with a small disk and five very slender terete rays. Radii of the type 4.5^{mm} and 23^{mm}; ratio, 1:5.1.

The dorsal surface is evenly covered with very small irregular plates many of them roundish, forming a finely but rather evenly riticulated structure, in which the plates and ossicles are narrower than the sunken papular areas between them. The papulæ are mostly solitary. The madreporic plate is small, somewhat raised, nearly destitute of spinules.

The spinules are remarkable small and thin, almost microscopic in size, very slender and short. They are rather numerous on the larger plates, but are not crowded, partly owing to their thinness.

Plates of both marginal rows are very distinct, transversely oblong, nearly equal, and covered with numerous very minute, spaced spinules like those of the dorsals but a trifle larger. The two rows are separated only by a narrow naked groove distally, but at the base of the rays a few intermarginal plates lie between them.

The interactinal plates form a single regular row. They are squarish, about half as large as the marginals, and spinulated in the same way. There is a simple row of minute papular pores each side of the interactinal row of plates.

[10] Perrier gives this station erroneously as No. 47. It should be No. 45. He also errs in giving the longitude as 33° 21′ East. It should read 83° 21′ East. It is in N. lat. 25° 33′, Northwest of Dry Tortugas.

The adambulacral spines are very characteristic. There is a strictly marginal comb, directed horizontally across the groove, and composed proximally usually of three slender spines, webbed at base. Distally these spines are reduced to two and near the tip of the ray to one. Deep in the groove there is sometimes a minute furrow spine, especially distally, but proximally it is usually lacking or rudimentary.

On the actinal face of the plate there are numerous minute spinules, of which four to six, near the inner margin, become decidedly longer than the rest.

The adambulacral plates and spines project strongly into the groove, but are so much separated serially that they leave large rounded interspaces for the passage of the sucker-feet, which appear to be larger than usual.

Taken by the Albatross at station 2655, in 338 fathoms, north of Bahamas, N. lat. 27° 22′; W. long. 78° 7′ 30″. (No. 18,390, Nat. Mus.)

Family Solasteridæ Perrier.

Solasterinæ (sub-family of Echinasteridæ) Viguier, Squellette des Stellerides, Nouv. Arch. Zoöl. Exper., vii, p. 133, pl. viii, figs. 1-7, 1878, (structure).

Solasteridæ Perrier, Etoiles de mer, p. 210, 1884. Sladen, Rep. Voy. Chall., Zoöl., xxx, p. 442, 1889. Perrier, Exped. Trav. et Talism., p. 151, 1894. Fisher, op. cit., 1911*b*, p. 305. Verrill, op. cit., 1914*a*, p. 242.

Echinasteridæ (*pars*) Perrier, Revis. Stell., Nouv. Arch. du Mus., iv, p. 358, 1875.

Rays varying in number from five to thirteen or more. Dorsal skeleton generally formed either by openly reticulated or loosely imbricated (rarely detached) ossicles, which have a convex or elevated central boss, bearing a cluster of slender paxilliform movable spinules, webbed together into stellate or pencillate groups (pseudopaxillæ). Both series of marginal plates are usually distinguishable, at least distally, alternate or opposite, or nearly in one line. The upper ones are often the smaller and essentially like the dorsal pseudopaxillæ. Both rows bear paxilliform spinelets.

Actinal interradial pseudopaxillæ are generally present and similar to the dorsals. Adambulacral plates are transversely elongated and bear, each, one to five or more spines, usually

webbed, in a longitudinal row on the inner margin of the groove and one or more clusters or a transverse webbed series or comb of movable spines on the outer surface. True pedicellariæ are not known in most species, but large specimens sometimes have a few small bifid spines in the furrow series, and in *S. stimpsoni* a few minute simple bivalve pedicellariæ sometimes occur on the dorsal paxillar areas. Sladen (1888 and 1889) divided this family into two subfamilies: *Solasterinæ* and *Korethrasterinæ*. In this he was followed by Perrier (1894, pp. 154, 158). Later these have been considered separate families.

Genus Lophaster Verrill.

Lophaster Verrill, Amer. Journ. Sci. ser. III, xvi, p. 214 (type, *L. furcifer*), 1878. Expl. Albatross in 1883. Ann. Report U. S. Fish Comm., pp. 531, 541 [29, 39], pl. xvi, figs. 49, 49*a*, 1885. (*L. furcifer*); Amer. Journ. Sci., xlix, p. 201, 1895. Sladen, Voy. Chall., xxx, pp. 458-461, 1889. Fisher, op. cit., 1911*b*, p. 334.

Lophaster Verrill, op. cit., 1914*a*, p. 366.

Solaster (*pars*) Danielssen and Koren, Asteroidea, Norske Nordhavs-Expd. Zoöl., xi, p. 47, pl. viii, fig. 12; pl. ix, figs. 9-11, 1884 (structure).

Sarkaster Ludwig, Mem. Mus. Comp. Zoöl., vol. xxxii, p. 185, 1905 (t. Fisher).

Rays nominally five, sometimes six. Disk not very broad. Dorsal surface covered with nearly uniform paxilliform plates (parapaxillæ) which have a columar or raised boss, and a lobed polygonal or cruciform base; their lobes are articulated by overlapping, without intermediate ossicles, and thus form a closely reticulated structure with polygonal or subquadrate meshes, and usually solitary papulæ.

Marginal plates of both series well developed, in regular series, parapaxilliform, like the dorsals, but larger.

Interactinal plates closely united in interradial angles, with paxilliform spinules; a single row usually extends far along the rays in adult specimens, with or without spinules. Adambulacral plates have a furrow series of webbed spines, and a transverse comb on the actinal surface.

Species of this genus have been found in deep water, in all the oceans.

LOPHASTER RADIANS Perrier.

Korethraster radians Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 12, 1881.
Korethraster hispidus Perrier, Etoiles de Mer, p. 212, pl. vi, figs. 9-11, 1884 (*non* W. Thompson).
Solaster radians Perrier, Etoiles de Mer, p. 275 (in explanation of plates), pl. vi, figs. 9, 10, 11, 1884.
Lophaster radians Perrier, op. cit., pp. 167-170 (in lists of species), 1884.
Korethraster? radians Sladen, op. cit., p. 459 (footnote), 796, 1889.

Plate v; figure 2. Plate vii; figure 3. Plate xi; figures 1—1*c*.

Form stellate with a rather broad convex disk and short subacute rays. Radii of the largest (sta. 64), 17^{mm} and 40^{mm}; ;ratio, 1:2.4. It occurs with four to six rays, usually five. The dorsal skeleton is rather openly reticulated with large quadrangular papular areas and numerous large grouped papulæ.

The pseudopaxillæ are rather large and high, with an enlarged convex summit, which is covered with numerous (often forty to fifty) very slender, divergent, thorny spinules; those of the marginal fringe are longer and interlock across the spaces intervening between the plates. The spinules are hyaline and often forked at the tip, and diverge in all directions.

On the rays there is no evident median series, nor do the plates form many regular transversely oblique rows on the sides. The bases of the plates are mostly deeply four-lobed or substellate. Their arrangement is evidently in radial rows.

The two marginal rows of plates are very evident and pretty regular, and nearly opposite. The upper ones are rounded and very similar to the larger dorsals, and higher than the adjacent lateral ones. The inferomarginals are high, elliptical and nearly twice as large with a correspondingly larger number of terminal rough spinules on the convex summit.

There is a row of small peractinal plates, extending to about the distal fourth of the rays, and a few other interactinal ones on the small interradial areas. These have very slender, thorny spinules.

The adambulacral plates have a prominent convex inner margin, which bears a regular compact row of four or five long, slender, thorny, subhyaline furrow-spines, the middle ones longest. Their actinal surface bears a row usually of three or four similar rough spinules, but rather stouter. In this dry specimen there is no very evident web between these spines, except near

their bases. It is more evident in others, but it is thin and delicate.

The oral plates are large and have a broadly and evenly rounded margin, that of the pair combined forming a semicircle, and bearing along the edge a very regular compact row of eighteen slender subequal spines, nine to each plate. Epioral spines are also numerous and slender.

Ambulacral sucker-feet and their pores are very large, regularly biserial.

The type described by Perrier was smaller, radii 4^{mm} and 10^{mm}.

Perrier, in his report on the starfishes of the Blake Expedition (1884, pp. 167, 212, and 275), placed this species in three distinct genera, and under two different specific names (without explanations or cross references), as shown in the synonymy given above. His description was given under "*Korethraster hispidus*, sp. nov."; but it was a reprint of his earlier description (1881), which was given under *Korethraster radians*.

The name, *Lophaster radians*, occurs in his lists of species dredged; and *Solaster radians* occurs only in the explanation of plate vi. There is no reference to these figures in connection with the description. I am not aware that he corrected these references in any other later works.

The type of this species, described by Perrier, was quite young (radii 4^{mm} and 10^{mm}), only about one-fourth as large as the one now described. This will account for various differences.

Perrier recorded this species from off Barbados, in 56 fathoms, and off Havana, in 80 fathoms. It was also dredged at several stations in the West Indies, by the "Albatross."

It was taken by the Bahama Expedition at several stations. The largest, described above, was from station 64, in 110 fathoms, off Florida. Smaller ones occurred at sta. 28, off Sand Key, in 116 fathoms; and at sta. 56, Pourtales Plateau, in 200 fathoms. Another (radii 10^{mm} and 33^{mm}) was from station 62, off Florida, in 80 fathoms.

Genus Solaster Forbes.

Solaster (*pars*) Forbes, Mem. Wern. Soc., viii, p. 120, 1839; British Starfishes, p. 109, 1841. Gray, Ann. and Mag. Nat. Hist., vi, p. 183, November, 1840; Synopsis, p. 4, 1866. Verrill, Proc. Boston Soc. Nat.

Hist., x, p. 345, 1866 (*Solaster* and *Crossaster* first separated). Agassiz, North American Starfishes, pp. 111, 112, 1887 (structure). Perrier, Exped. Trav. et Talism., p. 154, 1894. Sladen, op. cit., p. 450, 1889. Verrill, North Pacific Starfishes, p. 242, 1914*a*.

Solaster (*pars*) Viguier, Nouv. Arch. Zoöl. Exper., vii, p. 138, 1878 (structure).

Solaster (*pars*) Danielssen and Koren, Norw. N. Atlantic Exp., Asterioidea, pp. 42, 52, 53, 1884 (structure). Fisher, op. cit., 1911*b*, p. 306.

Crossaster (*pars*) Müller and Troschel, Monatsb. Preuss. Akad. Wiss., Berlin, April, 1840, p. 103.

This genus includes large, handsome, multirayed species, usually with a broad disk and slender rays.

The rays are seven to fifteen, variable in each species, but most frequently ten to twelve. Dorsal ossicles small, mostly slightly four-lobed, sometimes stellate, usually reticulated, or in quincunx, on the disk and proximal part of the rays, but closely imbricated near ends of the rays, and often arranged in regular quincunx order on the sides of the rays. They are convex or mammillate, with a central boss, and bear a stellate or fasciculate cluster of slender spinules, webbed together, and usually enclosing one or several central spinules, connected by the web, forming pseudopaxillæ. The outer circle of webbed spinules often forms a funnel-shaped structure in life, or when well preserved; but the spinules are movable, and in dry specimens they are usually mostly collapsed or tipped over, thus forming irregular groups or pencils of small spinules, from five to twenty or more in a group.

The superomarginal plates are small and close to the larger inferomarginals, usually alternating. They are frequently hardly distinguishable from the dorsal pseudopaxillæ, except near the ends of the rays, but they extend regularly to the apical plate.

Inferomarginals are much larger and more elevated, usually transversely oblong, forming a rather conspicuous row. They bear a large number of paxilliform spinules in two or more transverse rows. Adambulacral plates usually have three to six shorter groove-spines, webbed together, and an actinal transverse row of four to nine or more longer spines, also webbed.

The interradial actinal areas are small, but distinct, and bear pseudopaxillæ, much like the dorsal ones.

Papulæ are numerous on the dorsal surface, but stand singly

or in small groups. A single row of peractinal pseudopaxillæ usually extends along the proximal part of the rays, to about the middle.

SOLASTER CARIBBÆUS Verrill, sp. nov.

Plate xxviii; figures 1—1*a*. Type.

Disk rather large; rays seven or eight; most often eight, rather short. Radii 14^{mm} and 36^{mm}; ratio, 1:2.6.

The rays are rounded above and taper regularly. They are closely covered with very small, elevated pseudopaxillæ, having very small spinules. Papulæ are numerous, but mostly solitary. Both rows of marginals are distinct and alternate. The upper ones are much the smaller, compressed, and not much larger than the dorsals.

The inferomarginals are more than twice larger, transversely oblong, and bear two or more rows of short spinules.

The adambulacral plates have an inner or furrow-comb of three or sometimes four graded, webbed spines, the middle ones longest; and a transverse actinal comb of about four larger tapered spines, of which the second and third are the larger.

The jaws have a peroral row of about eight relatively long, tapered, subacute, graded spines (four on each side), of which the two middle ones are considerably longer and larger than the next, while the latter are about twice as long as the third.

All the specimens are quite young. Taken by the Albatross at several stations in the West Indies.

Family KORETHRASTERIDÆ Dan. and Kor.

Korethrasteridæ Danielssen and Koren, Asteroidea, Norske Nordhavs-Expd. Zoöl., xi, p. 99, pl. xii, figs. 1-14, 1884 (structure). Fisher, op. cit., 1911*b*, pp. 252, 340.

Korethrasterinæ (subfamily of Solasteridæ) Sladen, op. cit., p. 462, 1889. Perrier, Exped. Trav. et Talism., pp. 151-154, 158, 1894 (descr. and analytical table).

Stellate starfishes with short rays and convex disk, flat below. Dorsal surface covered with thin, flat, roundish plates, overlapping by their edges, with a boss in the middle, bearing a fascicle of long, divergent spinules. Inferomarginal plates are trans-

versely elongated, their outer ends forming the margin, and bearing spines.

Adambulacral plates correspond with the inferomarginals and join them. They bear a transverse row of slender spines, usually without webs. Interactinal plates are usually lacking.

Jaws carinate, with a row of several adoral spines and a larger terminal pair; actinal surface with a pair of larger epioral spines.

Dorsal papulæ are said to be lacking in the type genus; they are present in *Remaster.*

Genus REMASTER Perrier. Type *R. palmatus* Per.

Korethraster (*pars*) Perrier, op. cit., 1881, p. 12; Etoiles de Mer, p. 211, 1884.

Remaster[12] Perrier, op. cit., pp. 150, 161, 1894 (as subgenus).

Dorsal plates have a four-lobed base, the lobes overlapping, leaving large papular pores between them; from the central boss arises a divergent circle of slender webbed spinules.

Inferomarginal plates form the border and bear marginal spines. Two or three rows of imbricated interactinal plates on the rays, corresponding to the adambulacrals, and bearing about two webbed spines. The jaws have large epioral spines.

REMASTER PALMATUS Perrier.

Korethraster palmatus Per., Bull. Mus. Comp. Zoöl., ix, p. 12, 1881; Nouv. Arch. du Mus., vi, pp. 311, 376, pl. viii, figs. 5, 6, 1884. Sladen, op. cit., pp. 463, 796, 1889.

Korethraster Nutting, Narrative, p. 167, 1895.

Remaster (subgenus) *palmatus* Per., Exp. Trav. et Talism., pp. 158, 161 (redescribed), 1894.

Plate xi; figure 2.

The type of Perrier had the radii 4.7^{mm} and 14^{mm}; ratio, 1:3.

The form is stellate, with a swollen disk and short rays.

On the dorsal surface a deep interradial groove runs up to the dorsal pore, dividing the disk into five parts. The dorsal pore is surrounded by granules, but has no visible plates.

Five primary radial plates are distinguishable. The rest of the radial areas are covered by squarish plates, with emarginate

[12] The name refers to the large flat oral spines (t. Perrier.)

sides and rounded angles, and imbricated by the two distal lobes of each, overlapping the edge of the two plates beyond it. Thus each plate joins four others.

Each dorsal plate has a round central boss, carrying a fascicle of ten to twelve long (about 1^{mm}), slender, movable, webbed spinules capable of becoming either divergent or fasciculate. Two large isolated papular pores are situated on the adoral side of each plate in the notches.

The adambulacral plates are short, but elongated transversely. Each has a single small furrow-spine, and on its actinal side three large flat, striated spines, truncated and fringed at the tip, each of which seems to be composed of three united slender spines. These form three longitudinal rows.

Outside of the adambulacrals is a range of imbricated plates, corresponding to them in length, but a little oblique. Each of these bears a flat fascicle of coalesced spinules like those of the adambulacral plates. These are succeeded by an outer row of similar, but less regular, plates which form the margin of the under side.

Each jaw-plate bears a large, flat, lanceolate, hyaline spine, turned outward and appressed. Other oral spines are small and webbed together.

Ambulacral feet are rather large, in two regular rows, with well developed suckers.

The type was taken by the Blake off Barbados, in 163 or 200 fathoms, with three others; a young one was taken near the same place in 76 fathoms. It was also dredged in the West Indies by the Albatross.

Taken by the Bahama Expedition at station 56, on the Pourtales Plateau, N. lat. 20° 16′, in 200 fathoms (3 specimens).

Family Asterinidæ.

Asterinidæ (*pars*) Gray, Ann. and Mag. N. Hist., vi, p. 238, 1840; Synopsis, p. 15, 1866. Perrier, Revis. Stell., iv, p. 291, 1875; v, p. 209, 1876. Viguier, Squellette des Stell., Arch. Zool. Exper., vii, p. 205, pl. xiv, figs. 1-13, 1878 (structure). Sladen, Voy. Challenger, xxx, p. 374, 1889. Perrier, Expl. Trav. et Talism., pp. 141, 163, 1894. Fisher, op. cit., 1911, p. 253 (Table of genera). Verrill, Revision Asterininæ, Amer. Journal Science, vol. xxxv, p. 477, 1913 (Table of genera); Starfishes North Pacific Coast, p. 262, 1914*a*.

Body usually rather flat, often thin, sometimes stellate with long rounded rays; usually with five or six short rays, rarely up to eight. Margins usually thin and formed mainly by the inferomarginals; superomarginal plates small, usually scarcely larger than the adjacent dorsals, generally with a comb or cluster of spinules. Dorsal plates usually lobed or cross-shaped, flat and more or less imbricated, sometimes not imbricated; generally covered with minute spinules, often in tufts or combs; sometimes covered with a soft, naked, or granular dermis. Ventral side flat; interactinal plates angular, flatish, imbricated or closely united, usually covered with small combs or tufts of spinules, sometimes with only one; these plates form regular oblique rows. Adambulacral spines simple, divergent; generally in two sets; the furrow-spines form small, usually webbed combs of two to eight. Those on the outer surface are in groups or fans, like the interactinals, or single. Pedicellariæ usually lacking; when present they are two-bladed, erect, forficiform.

There is generally no single, dorsal, median, radial row of plates; its place is taken by two, three or more alternating rows; the larger of these plates have a papular pore or several pores under the proximal edge. In some cases, especially while young, there is a symmetrical median row of plates. These larger plates usually show only one of the edges and part of one side; seen from the inside they appear much larger, often four-lobed, and obliquely imbricated. The dorsal plates of the outer interradial areas, in many species, have conical or pillar-like processes extending downward and meeting similar uprising processes from the outer interactinal plates, as stalactites meet stalagmites; or they may not join directly, but be united by an intermediate ossicle. In some genera they are differently joined. In typical *Asterina*, and doubtless in many other genera, if not in all, the genital pores are on the ventral side, in a pair, just outside the jaw plates, but they are seldom visible in preserved specimens. The madreporic plate is usually rather large and placed close to the central area of the disk; sometimes there are two or more, rarely five.

The papular pores are dorsal and form several rows on the median and lateral parts of the rays, and sometimes on adjacent parts of the disk, but are absent from the more or less extended

interradial areas, where the plates are more closely imbricated and different in shape.

ASTERINIDES Verrill. Type, *A. folium* (Ltk.)

Asterina (pars) Lütken; Sladen; Perrier, etc.
Asterinides Verrill, Revision Asterinæ, pp. 477, 482, 1913. N. Pacific Starfishes, p. 263, 1914*a*.

Margins of disk and rays thin, subacute; rays short, depressed.

Interactinal or ventral plates in regular oblique rows, each with a fan-shaped group of two to eight small spines, usually webbed.

Dorsal plates of papular areas thin, nearly all of one kind, the exposed part usually roundish, elliptical, or shield-shaped, wholly or partly spinulose. Principal dorsal plates are all closely imbricated. Small interpolated plates few and mostly solitary. Adambulacral spines form a fan or comb within the furrow-edge, and another fan on the outer surface; ventral plates and interspaces are not covered by a granulated dermis. No pedicellariæ occur on the dorsal plates nor on the intervening dermis.

This genus differs from typical *Asterina*, type, *A. gibbosa*,[13] chiefly in lacking the characteristic pedicellariæ of that genus. Its dorsal plates are also thinner and more scale-like, more closely imbricated, and often partly naked and areolated.

ASTERINIDES FOLIUM (Lütk.) Verrill.

Asteriscus folium Lütken, Vidensk. Nat. Foren., Kjobenhavn, p. 60, 1859.
Asterina folium A. Agassiz, North Am. Starfishes, p. 106, pl. xiv, figs. 7-9, 1877. Sladen, op. cit., 1889, p. 393.

[13] *Asterina gibbosa* (Pennant). This, which is the type of the genus and family, is from Southern Europe and the Mediterranean Sea.

It has the following characters: Dorsal plates, in the papular areas are thick, subequal, imbricated; their exposed proximal ends are rounded, convex, with the margin obtuse and bearing a cluster, usually of four to six small, rather stout, divergent, blunt spinules, and more or less numerous two-bladed pedicellariæ, both on the plates and between them, nearly as thick as the spinules; naked portion of the plates is finely areolated. The median plates of the rays are scarcely larger than others; usually there is a band of four alternating rows on the median area, with no special median row, unless in the young. The plates of the median radial areas are shield-shaped, with a pair of papular pores on the proximal edge, one either side

Asterina minuta Gray, (non Gmel., *nec* Brug.[14]) Ann. Mag. Nat. Hist., p. 289, 1840; Synopsis Starfish, p. 16, 1866. Perrier, Arch. Zoöl. Exper. et Gen., v, p. 229, 1876.

Asteriscus folium Verrill, Trans. Conn. Acad. Sci., i. p. 74, 1867.

Asterina folium Verrill, Trans. Conn. Acad. Sciences, vol. xii, p. 281, pl. xxxiv, c, figs. 3, *a*, *b*, 1907.

Asterinides folium Verrill. Revision Asterininæ, p. 479, figs. 1913*a*; Starfishes N. Pacific, p. 263, 1914*a*.

Plate iii; figure 5. Plate xi; figure 4. Plate xxviii; figure 2.

The rays are usually five; sometimes six or four. The dorsal plates are usually nearly naked, often bearing only a single or double range of small and short spinules on the most elevated portion. Dorsal radial plates are shield-shaped, notched for the isolated papular pores. Papular pores form six simple radial rows. They are absent from the interradial areas.

Plates of the interradial areas are closely imbricated, not lobed; their exposed part is more or less rhombic.

The interactinal plates are closely united; each bears a fan of usually three or four, sometimes five on the larger ones, of slender webbed spinules.

Adambulacral plates have, in the furrow-comb, about four slender spines, and three or four in the actinal cluster. The madreporite is near the central area of the disk. There are no pedicellariæ.

A specimen before me, from Curacoa, has the radii 6^{mm} and

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of the median angle, in an emargination of the edge. Small intermediate plates are few and isolated.

The papular pores form about fourteen to eighteen short rows, extending nearly to the margins and leaving only small interradial areas without pores.

Adambulacral furrow-spines slender, in regular combs of three to five; those on the outer surface are much stouter, mostly two to a plate. Interactinal plates closely united, mostly with two acute spinules to a plate.

Marginals very small, those of the two rows subequal, convex, finely spinulose.

The pedicellariæ have the basal piece swollen, ovate, larger than the tapered acute blades. They stand at all angles on dry specimens, but were probably erect in life.

[14] The *Asterias minuta* of Gmelin, 1788, and of Brugières, 1792, is without much doubt the same as *A. exigua* Lam., but certainly not the present species.

11^{mm}; ratio, 1:1.8. It is the same one from which figures of the details of structure have been made.

The rays are convex; ends obtuse. All the plates of the upper side were naked, as received, dried. Probably they had some spinules originally. The plates are minutely punctulate, and closely imbricated.

Two alternating rows of plates, slightly larger than those adjacent, take the place of a median radial row. They are angularly shield-shaped. The adcentral edge is slightly raised and emarginate to accommodate the single papula standing there. No small intermediate plates are now left.

The plates in the rows of the sides of the rays, where there are papular pores, are similar to the median ones, but slightly smaller and mostly notched for the papula. They are somewhat oblique or one-sided.

The papulæ are in six rows on the rays; others are on the disk. The central dorsal pore is easily seen. The madreporic plate has a small convex, round, grooved top, but the basal part is considerably larger, with lobed margin, and has no gyri.

The adambulacral plates have four very slender graded spines in the marginal comb, and a close group of two, or sometimes three larger ones, on the actinal surface. The interactinal plates have mostly two or three small spinules. The apical peroral spines are large and acute. Curacoa, No. 7469 (Nat. Mus. coll.).

The color, in life, seems to be quite variable. At Bermuda, where I found it common, adhering to the under side of large flat masses of limestone, it was always of a pale, but distinct, blue color.

This small species is the most common shallow-water member of the family, from the Florida Keys and reefs to the Lesser Antilles and to the Bahamas and Bermudas. Curacoa (Yale Mus. specimen described). Perrier (1876) recorded ten specimens from Guadeloupe, among which one had four and another six rays. The Bahama Expedition took it at the Tortugas (one specimen was six-rayed), Jamaica (Clark).

Bermuda, common under large stones. Old Providence (Yale Mus.).

The only closely related species is *A. modesta* Verrill, from

Panama. For the sake of comparison a revised description of the latter, from the type, is given here.

Asterinides modesta Verrill.

Asterina modesta Verrill, Trans. Conn. Acad. Sci., vol. i, p. 277, 1867.
Asterinides modesta Verrill, op. cit., p. 482, 1813.

Plate xxvii; figures 1—2.

Rays five, short. Dorsal radial plates are thin and closely imbricated, with a convex outer surface; beneath concave, over the isolated papular pore. A solitary, small, rounded plate stands adcentrally to the papular pore; it bears a tuft of small, slender spinules like those of the larger plates. The latter have, near their higher margin, a row, usually single, of small, slender, acute, divergent, thorny spinules. Pedicellariæ are lacking.

The interactinal plates are few, convex, minutely punctulated. Most of them bear a comb or fan of two or three slender spinules.

Adambulacral plates have a furrow-comb of about three slender, tapered spinules.

Panama and Pearl Islands at low tide. (Yale Museum.)

Genus Enoplopatiria Verrill. Type, *E marginata* (Hupé).

Enoplopatiria Verrill, Revision Asterininæ, p. 480, 1913*a*. Starfishes N. Pacific, p. 263, 1914*a*.

Dorsal plates are imbricated; a median radial row is distinct in the young. The principal plates of the papular areas have the exposed portion usually elliptical, curved, or crescent-shaped, prominent and spinulose; small interpolated plates are present in small groups or solitary. Ventral plates have a fan of two to five spinules; adambulacrals have a furrow-comb of three to five or more spines. Pedicellariæ are present on the dorsal plates, especially on the small interpolated plates.

In this group the papular area is plainly differentiated on the rays; it consists, in the adults, of about four or five median and submedian rows of larger and broader, four-lobed or five-lobed plates, curved and notched proximally for the papular pores, and of two or three rows of narrower, obliquely placed, lobed plates, having an angular proximal lobe, and notched proximally over the papular pore.

Between all the larger plates are a few small rounded plates, either solitary or in small groups, and often bearing a single bivalved pedicellaria.

On the dorsal interradial areas, beyond the papulæ, the plates are smaller, closely imbricated, subtriangular or pelecoidal, thickened, usually with a solitary small ossicle between their angles.

Enoplopatiria marginata (Hupé) Verrill.

Asteriscus marginatus Hupé, Voyag. Castelneau, Zoöl., iii, p. 100, 1857. Perrier, Pedicell., p. 97, 1869.

Asteriscus braziliensis Lütken, op. cit., 1859, p. 57.

Asteriscus stellifer Mobius, Hamburgur Abhand. Geb. Natur., iv, 1859. Verrill, Trans. Conn. Acad., i, p. 343, 1867.

Asteriscus minutus (*pars*) M. and Tr., System Aster., p. 41, 1842. (*non* L., *non* Gmel., *nec* Gray, etc.)

Enoplopatiria marginata Verrill, Revis. Asterininæ, p. 480, 1813; Starfishes N. Pacific, p. 263, 1914*a*.

Plate vii; figure 2. Brazil.

Depressed, stellate, with short, rather obtuse rays, and rather evenly incurved interradial margins. Becomes 65^{mm} or more in diameter. Larger dorsal plates rather conspicuous with thickened exposed portions, mostly broad crescent shaped. The larger ones bear a curved single or double row of about six to twelve spinules, not covering the whole surface, and usually several forked pedicellariæ, with a large rounded basal piece, nearly as thick as the spinules. A similar pedicellaria is usually borne on each of the small interpolated plates.

Small specimens, up to 70^{mm} in diameter, usually have a distinct median dorsal row of subrhombic or shield-shaped plates, flanked on each side by a row of obliquely placed plates of similar size, but less symmetrical. Larger specimens usually show the median row of plates proximally, but on the distal third or half of the ray the dorsal rows of plates become confused and crowded irregularly.

The plates of the dorsal interradial areas are regularly imbricated in alternating rows, becoming thicker proximally, and often have a small central boss. They bear a group of small divergent spinules.

The ventral or interactinal plates are regularly arranged in

oblique rows, thickened or convex, with a finely areolated surface, and bearing a central fan of two to five or more spinules. The smaller specimens usually have only two or three spinules; larger ones may have four or five on the proximal ones and two on the distal ones.

The proximal plates are so arranged that in the dry specimens a distinct pore, similar to the dorsal papular pores in size, is situated between their angles, but whether occupied by a papula cannot be ascertained from the dry specimens. The furrow-series of spines form a regular graded, webbed comb of about four or five on each plate, the central spines longer. On the actinal end of the plate there are usually two to four webbed spines, in a fan, the number increasing with the age.

West Indies; Colon; south to the Abrolhos Reefs, and Rio de Janeiro, Brazil. West Africa; Senegal (Perrier); Canary Islands.

Perrier records a six-rayed example from Brazil.

The Yale Museum has specimens from Rio de Janeiro (coll. C. F. Hartt, No. 5205) and other localities.

Perrier and several others regard the West African species (*E. stellifera* [Mob.]) as identical with that of the American coast. I have seen no African specimens and cannot express any personal opinion as to their identity.

The following species, from Panama, is very closely related to the above.

Enoplopatiria siderea Verrill.

Enoplopatiria siderea Verrill, Revision Asterininæ, p. 480, 1913; Starfishes N. Pacific, p. 365, pl. cix, fig 3, 1914*a*.

Plate xxvii; figures 3—3*a*. Type.

This is a rather large species. The type (dry) has the radii 24^{mm} and 45^{mm}; ratio, 1:1.83.

It differs from the preceding in having the principal papular plates larger, thicker, more deeply lobed, and more finely areolated; in having the distal, dorsal interradial plates more rounded, and provided with very regular stellate rosettes of five to seven slender, divergent, interlocking spinules, and often one

central spine. Combs of ventral plates have two to four slender, tapered, subequal, webbed spines, but mostly three.

Furrow-spines are in convex combs of four or five slender, webbed spines. Ventral plates are covered with a tough dermis. Pedicellariæ are abundant, two-valved. Marginal plates small, convex, regular, about equal, regularly paired; lower ones are the more prominent.

Panama. One dry specimen, presented by Capt. Dow (Yale Univ. Mus.).

Genus ASTERINOPSIS Verrill. Type, *A. penicillaris* (Lam.).

Asterinopsis Verrill, Revision Asterininæ, p. 480, 1913.

This genus is peculiar in having a fascicle of slender spinules on the ventral plates, instead of a fan-shaped group, which is usual in the family. Pedicellariæ are lacking. The dorsal and marginal plates also bear fascicles of slender spinules. Adambulacral furrow-spines are in regular combs. The principal dorsal plates are lobed or cross-shaped.

In addition to the type, which is Indo-Pacific, this genus includes the following two species.

ASTERINOPSIS PILOSA (Perrier) Verrill.

Asterina pilosa Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 16, 1881; Nouv. Arch. Mus., vi, p. 219, pl. iii, fig. 8, 1884.
Asterinopsis pilosa Verrill, Revis. Asterininæ, p. 480, 1913.

This species was described from a single six-rayed specimen; radii 6^{mm} and 10^{mm}.

It is evidently very closely related to the *A. lymani* and may not be distinct from it. As in the latter the ventral and dorsal plates bear fascicles of elongated, slender spinules, appearing silky. They agree in having six rows of papulæ; four slender spines in the furrow-combs; and in most other respects. Off Dominica I., 118 fathoms, Blake Expedition.

ASTERINOPSIS LYMANI (Perrier) Verrill.

Asterinopsis lymani Verrill, op. cit., 1913, p. 480.
Asterina lymani Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 15, 1881; Nouv. Arch. du Mus., vol vi, p. 219, 1884.

The following notes were made by me several years ago, on the type specimen preserved in the Museum of Comparative Zoölogy.

Rays unusually long for this group. Principal dorsal plates are small, lobate or cross-shaped, separated by numerous rather large papular pores; they bear close pencils of rather long, slender spinules, ten or twelve or more in each pencil. The spinules of the plates in the interradial areas are more slender and divergent.

On the actinal side the outlines of the interactinal plates are not distinguishable; each plate bears a group or pencil of four to six very slender, long, acute spinules, longer than those of the dorsal plates. Marginal plates very prominent, but not very large; not flat. Each bears a terminal close cluster of long, slender spinules, like those of the interactinal plates. The adambulacral plates bear a comb of about four or five slender, acute, regularly placed spinules in the furrow-series, and a group of three to six similar spinules on the outer surface.

The type was dredged by the Blake Expedition, off Barbados.

Genus STEGNASTER Sladen. Type, *S.* WESSELI Per.

Stegnaster Sladen, Voy. Chall., xxx, p. xxxiv, 376, 1889. Fisher, op. cit., p. 254, 1911*b*. Verrill, Revision of Asterininæ, p. 481, May, 1913.

Form depressed, pentagonal or stellate, with very short rays; margin thin.

Adambulacral spines form a continuous webbed series, the individual combs of three to five being united together; no spinules on the outer surface. Dorsal and ventral plates imbricated and, like their interstices, covered with a finely granulated dermis, which also forms a web between the minute spinules forming a feeble fan, on the interactinal plates. No dorsal spinules. Papular pores form six or more rows on the rays. Internal dorso-ventral columns are present near the margins. Form depressed, pentagonal, with thin margins. A few small ossicles occur between the dorsal plates; usually solitary. No pedicellariæ have been observed.

Besides the typical species, this genus seems to include *S. inflatus* Hutton, of New Zealand.

STEGNASTER WESSELI (Perrier) Sladen.

Asterina wesseli Perrier, Arch. Zoöl. Exper. et Gen., vol. v, p. 231, 1876; Etoiles de Mer., p. 220, 1884.

Stegnaster wesseli Sladen, Voy. Chall., xxx, p. 778, 1889. Verrill, op. cit., p. 481, 1913.

Plate iii; figures 3, 3*a*.

The form is pentagonal with emarginate sides, or substellate, with very short, wide rays. Radii of one of the larger specimens, 16^{mm} and 20^{mm}; ratio, 1:1.5. No. 758, Yale.

Central part of dorsal surface is convex. The dorsal surface is everywhere covered with a granulated dermis, both on and between the plates. The granules are minute, but sharp and rough. The larger plates of the papular areas are convex, curved and deeply notched for the papular pores; in front of the notch is a small ossicle, bordering the pore proximally.

The interactinal plates are rather thick, closely imbricated, and covered, together with their interspaces, by a sharply and densely granulated dermis, which also invests the bases of the row of minute spinules; it also forms a continuous web nearly to the tips of the marginal adambulacral spines, uniting them in an uninterrupted series to the ends of the rays; it also covers the jaws and peroral spines, the granules becoming there higher, like small acute spinules. Many of the interactinal plates bear a small transverse group or rudimentary fan of two to four very small, sharp spinelets, which are much obscured by the surrounding granulated skin. The granules are pointed, rough, and crowded.

The furrow-spines are sub-equal, slender, obtuse, mostly two or three to a plate, standing in a nearly straight row.

Dorso-ventral pillars or trabeculæ are well developed, rather stout, often curved. Jaw-spines form a continuous series with about six or seven on each side, grading into and united with the adambulacral row; apical ones stouter. No epioral spines seen. A pair of small pores, probably genital, are situated in each interactinal area, one on either side of the convex outer end of the jaw-plates.

The central part of the dorsal side of the disk is surrounded by five larger and more prominent lunate plates, which are the

basal radials or carinals. The madreporite, which is triangular, small, and depressed, is bordered externally by two smaller lunate plates, just outside the row of basal carinals.

The interradial areas, destitute of papulæ, are relatively extensive, running up in a narrow area, nearly to the central pentagon. The plates on the interradial areas are rhombic, closely united, and a little convex.

The median line of each ray is occupied by a row of small elliptical plates, elongated radially, without papulæ. The papular pores are large, round, and form six radial rows, where most developed; a few are situated on the central area of the disk. Superomarginal plates are transversely oblong, sometimes constricted across the middle, or double, and about twice as large as the roundish infero-marginals; the latter, however, project a little more and thus form the edge of the margin. Both series are covered with sharp granules, like the dorsals. No pedicellariæ were found.

Variations.

A somewhat smaller alcoholic specimen (diameter 28^{mm}) appears somewhat different. The principal dorsal plates are more distinct and appear more convex and more regularly arranged. The outlines of many of the plates can be seen under the granulated dermis. The upper marginal plates show their outlines beneath the granules. When the granules are cleaned off, they are oblong with rounded angles, with the longer axis transverse to the disk-margins. They are of the same width and number as the lower plates, and about twice as long, vertically. Their width is about the same as that of the adjacent abactinal plates, and they are covered with the same form of granules. Ventral interradial plates bear somewhat prominent flattened fans of minute spinules, webbed together at their base and showing three to seven small points at the outer edge. Jaw-plates are raised in the middle in the form of low verrucæ, covered with uniform and very small spinules. The peroral spines are slender, rather longer than the adambulacral spines, and closely webbed together. The adambulacral spines are free only at the tips, the web being continuous along the whole length of the groove.

Off Florida; Bahamas; Jamica; West Indies generally; Colon (coll. W. F. Bradley, Yale Mus., No. 758).

Family Poraniidæ Perrier.

Gymnasteriadæ (*pars*) Perrier, op. cit., 1884, pp. 165, 229, Sladen, 1889, p. 355.

Poraniidæ Perrier, op. cit., 1894, pp. 163, 227.

Asteropidæ (*pars*) Fisher, Smithsonian Misc. Coll., vol. 52, p. 90, 1908; op. cit. 1911*b*, p. 247. Verrill (*pars*), op. cit., 1914*a*, p. 304.

Disk usually large; rays short and broad. Dorsal ossicles sometimes in regular radial rows, on subimbricated, more often irregular, sometimes partly abortive, either covered with a thick, smooth or granulated dermis, or spinulose.

Marginal plates sometimes prominent; often small; usually oblique or overlapping; the lower ones projecting, and often with a small group of spinules on the outer edge, or with a single spine.

Interactinal plates often numerous; usually in regular oblique rows or chevrons or else in rows running to marginal plates. Papulæ in dorsal radial areas; sometimes interomarginal. Pedicellariæ lacking.

Adambulacral spines may form a simple row, transverse to the groove, or there may be also an inner comb of two, three or more, often partly rubbed.

The structure of some of the genera is very much like that of the Asterinidæ, with which the group might, perhaps, be united as a subfamily, without doing violence to their natural affinities.

The genus *Poraniella*, recently described, is more nearly intermediate than any other.

It is intended here to separate those genera of Asteropidæ closely related to the type, and especially those having bivalve or trivalved pedicellariæ, as a distinct family of the Valvulosa. Poraniidæ appear to belong rather with the Spinulosa, next to Asterinidæ.

Genus Poraniella Verrill.

Poraniella Verrill, Annals and Mag. Nat. History, vol. xiv, p. 19, July, 1914*c*.

Small starfishes with short rays. Dorsal surface covered with flat imbricated plates, in regular radial rows on the rays, not concealed by dermis, and bearing few spaced marginal spinules; medial radial row is distinct. Papulæ are isolated and placed under the proximal edge of the radial plates.

Superomarginal plates well developed, larger than dorsals, naked, or with few spaced submarginal spinules.

Inferomarginal plates are about as large as the upper ones, more prominent and form the thin margin; their outer edge has a comb of slender spines; their upper surface has a second parallel row of small spines, no papulæ pores between the rows.

Interactinal plates are imbricated in regular chevrous, each of which, except the first, has an impaired median plate. Most of these plates have two or three spinules standing side by side, otherwise the plates are naked.

Adambulacral plates have a horizontal regular inner comb of about three small spines discontinuous with the spines on the actinal face, which stand in a transverse line, usually of two or three. This genus resembles *Asterina* and *Asterinides* pretty closely, not only in appearance, but also in the arrangement of the imbricated dorsal plates and their spinules, and the position of the papulæ. The plates are larger, however, and do not become so numerous and small toward the margins. The marginal plates are much larger, and thicker, and therefore the margin is not so thin and acute.

The interactinal plates and their spinules are much as in *Asterina*, though larger and much fewer. The presence of a regular furrow-comb of adambulacral spines is another similar feature, though the spines on the actinal face stand in a transverse row, not as they do in *Asterina.*

This genus, therefore, is a sort of connecting link between Asterinidæ and Poraniidæ. Its affinities seem, on the whole, to be more with the latter, though the thick dermis found in most genera of the latter is lacking. The genus most nearly related is, perhaps, *Lasiaster* [15] of Sladen, if this be distinct from the earlier genus *Rhegaster* Sladen, which is denied by some.

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[15] *Lasiaster* Sladen, op. cit., p. 371, 1889. All the plates, above and below, and both marginals covered with thick dermis and all have a compact cluster of numerous small spinules, but they are absent from the sutural lines. Superomarginal plates are rather large and their outlines are visible through the dermis. Inferomarginals not larger, but more prominent, finely spinulated on both sides and with a row of spinules on the outer end.

Adambulacrals have two furrow spines, nearly or quite side by side proximally and becoming oblique distally; actinal face has three spines in a

Poraniella also closely resembles, in general appearance, *Marginaster* of Perrier. The type of the latter (so designated by Sladen, 1889) is *M. pectinatus* Per. (1881.) This has a different structure of the dorsal skeleton and very different adambulacral spines, which do not form a furrow-comb. In fact, it is covered with a thick dermis and is, without much doubt, the young of a large species of *Porania* or some closely similar genus.[16]

The *Marginaster echinulatus* Perrier, is nearer *Poraniella* in structure, for it has furrow-spines in a comb of two or three and a transverse row on the actinal face as in the latter.

Poraniella regularis Verrill.

Poraniella regularis Verrill, Annals and Mag. Nat. History, vol. xiv, p. 19, July, 1914*c*.

Plate vii; figures 1—1*a*. Plate xv; figures 5—5*b*. Details.

A small depressed stellate starfish, with a wide and somewhat convex disk and short, rapidly tapered, subacute rays, with rather thin fringed margins. Radii of the type, 6^{mm} and 12^{mm}; ratio,

transverse row. Interactinal plates are in regular chevrons, each with a compact cluster of small spinules.

Type, *L. villosus* Sladen (1889), said by Sussbach and Breckner (op. cit., 1910, p. 219), to be the same species as *L. hispidus* (Sars, 1871); *P. rosea* Dan. and Kor. (1884); *Rhegaster murrayi* Sladen (1883); *Poraniomorpha spinulosa* Verrill (1879); *R. borealis* Verrill (1878). See *Plate x, figures* 3, 3*a*.

If this be correct, the name should be *Rhegaster hispidus* (Sars), for *Rhegaster* is six years earlier than *Lasiaster*. Our two New England species appear to me to be distinct and should be called *Rhegaster spinulosus* and *R. borealis*. See Verrill, 1914c, pp. 17, 18, pl. i, figs. 1*a*, 1*b*, 2.

The latter is very closely related to *R. murrayi*, the type of *Rhegaster*. It differs in having the interactinal spinules longer and in special clusters, but the whole dorsal and marginal surfaces are densely clothed with uniform erect miliary spinules, entirely concealing the plates and sutures, as in *Rhegaster*. Whether either of our species is the same as *Rhegaster hispidus* (Sars) I am not able to say. That is the earliest name of any species; *borealis* is next in order (1878.) In *Lasiaster* the spinules do not cover the sutures, and therefore the outlines of the plates are more or less visible, and the superomarginal plates are larger and thicker. See also 1914*c*, in Annals and Magazines Nat. History, vol. xiv, pp. 17, 18.

16 I have before me equally small specimens of *Porania insignis* V. and *Rhegaster spinulosus* V., which agree very closely with *Marginaster* in details of structure.

1:2. Marginal plates are eight in each row. The two series are not quite opposite.

The dorsal surface is covered with rather thin and relatively large imbricated plates, overlapping adcentrally, and adradially, forming rows subparallel with the median radial row. Two rows each side of the median radial row have plates larger than the median, flat, thin, imbricated toward the median, with the free edge curvilinear and slightly notched or crenulate, and bearing three to five minute, acute, marginal, appressed spinules. Rest of the surface without spinules and not obscured by dermis. Isolated small papulæ are situated adcentrally to these plates, one or two under the free edge of each, except distally. These are followed toward the interradial margin by two short curved rows of similar, but smaller, plates without papulæ between them.

The median radial row of plates is narrow but distinct. Close to the tip of the ray the plates are small and regular, angular, and lie flat, with no pores between. Soon they become notched and turned up with two papular pores under the free edge. Proximally they stand up nearly edgewise and become smaller and are depressed below the level of the adjacent rows of plates. They bear two or three minute acute marginal spinules. The basal radial plates are much larger, but stand up obliquely, showing only one edge and part of the side. Each bears five or six minute spaced spinules on the proximal margin, and three or four scattered on the surface.

At the base of the interradial areas are two similar closely joined or united plates, of larger size, with a notch between them, from which a narrow naked line runs down to the interradial margin. The small madreporite lies in, or partly above, the notch between two of these plates, which with the basal radials, form a raised rim, surrounding a central group of smaller plates, mostly rounded, and having few minute marginal spinules.

The superomarginal plates, which in the larger specimens number nine or ten, are rather larger and thicker than the radial plates, and a little convex, with curved outer and inner margins. Each one bears two (rarely one) small submarginal spinules on the outer side.

The inferomarginal plates are similar in size and number, but more prominent, with the edge rounded, forming a rather thin

scalloped margin to the rays. Each bears two rows of spinules; a short row of about three on the upper surface, which are acute and divergent; and a marginal row, usually of four slender half-webbed spines, the middle ones largest, so that the outline of the group is curved. On the under side they are naked, transversely oblong, and the surface is covered with microscopic, raised dots.

The interactinal plates form three regular chevrons, with a few additional small plates in the interradial angle. (In smaller examples there are but two chevrons). In the first series there may be twelve or more plates, all paired. In the second and third chevrons there is an impaired interradial plate. All these plates have two or three small acute spinules, near the aboral edge, standing side by side, and subappressed. The plates are somewhat imbricated, more or less ovate, or subangular with rounded lateral edges, variable in size. The surface is covered with raised microscopic dots and covered only with a thin dermis that does not conceal them.

The adambulacral plates are small; each has a regular furrow comb of three slender webbed spines, directed horizontally. On the actinal face, and separated from the inner ones by a naked groove, are two or three, usually two, larger divergent spines, standing transversely to the groove.

The adoral and epioral spines are similar to the ordinary adambulacrals, but rather larger and longer; the perorals are somewhat stouter and blunt.

This was dredged by the Albatross, off West Florida, at stations 2334 (No. 10,190, Nat. Mus., type) 67 fathoms; 2324, No. 10,129, 23 fathoms; 2333, No. 10,179, 169 fathoms; 2323, No. 18,484, in 163 fathoms. Also Bahamas, station 2649, No. 18,474, in 36 fathoms.

Young. The smallest specimen seen (No. 18,474) has the radii 4^{mm} and 6.5^{mm}. Marginal plates seven in each row.

The dorsal plates are arranged nearly as in the type, but the specimen is preserved in better shape and all parts are neatly regular.

The plates are not only much smaller, but lie flatter and their outlines are less distinct because the dermis is a little thicker, most of the plates bear one small sharp spinule, situated on the

inner edge, just over the papular pore, or between them when there are two pores.

The median radial row of plates is less compressed proximally than in the type, and less depressed, being nearly on the same level as those adjacent, but the plates have the same form, and distally near the ends of the rays they become flat, polygonal, and have no pores between them, as in the type; most of them bear a single median sharp spinule on the inner edge. There are three radial rows of plates on each side of a ray, the outer one of about three plates. Papulæ form two rows on each side of a ray, with a few in a third row. The five primary radial and five interradial plates are larger, thicker and more distinct than the rest, but are not turned up, as in the type, and they bear very few minute spinules. They surround a central area of small plates covered with dermis and bearing isolated spinules. A minute dorsal pore is present, surrounded by microscopic spinules; marginal plates are essentially as in the type, but all parts are much smaller, and the upper ones mostly bear but one minute spinule. The comb of marginal spinules and the inferomarginal plates are largely webbed and the spines are very slender.

Interactinal plates form two chevrons with a few of a third, most of them have two small webbed spines on the aboral end.

Adambulacral spines are like those of the type, but much smaller.

Other specimens are intermediate in size between the above and the type, and have intermediate conditions, as to plates and spinules, but all agree so closely that their identification is easy.

PORANIELLA ECHINULATA (Perrier) Verrill, 1914*c*.

Marginaster echinulatus Perrier, Bull. Mus. Comp. Zoöl., ix p. 17, 1881; Etoiles de Mer, p. 230, pl. i, figs. 6, 7; Exped. Trav. et Talism., p. 169, 1894, (redescribed). Sladen, Voy. Chall., xxx, 366, 1889.

Poraniella echinulata Verrill, Annals and Mag. Nat. History, vol. xiv, p. 20, July, 1914*c*.

Radii of the type are 3^{mm} and 5^{mm}; ratio 1:1.66. The form is somewhat stellate. According to Perrier (1894) the type has the following characters:

On the dorsal side the central plate is surrounded by ten plates, five larger basals (interradials), and five radials, the last two

sets are in contact. The radials are pentagonal. In this central area are no papular pores, but a large one stands next to the suture between the radials and basals.

The carinal row, beyond the basal, has five pentagonal plates. The proximal lobe overlaps the edge of the preceding plate, and has a papular pore each side of it. The other dorsal plates, similar in form, are in oblique short rows that run from the carinal to the marginal plates; the first row has three plates; the second and third two plates each.

There are isolated papular pores each side of the plates of the first row, forming four radial rows of pores. There are also two rows of small interradial plates.

The dorsal plates mostly bear from one to three small spines. No pedicellariæ were found.

The superomarginal plates are four to each side of a ray; they are longer than wide, destitute of a marginal row of spinules, but bear small scattered spinules. The ocular plate is rather large, ovate, unarmed. The inferomarginals are five to each side of a ray. They are longer than wide and each bears a row of five to seven marginal spinules, which are short and divergent, forming a marginal fringe. The distal plates are very small.

The few interactinal plates form two chevrons. The first has no impaired interradial, each of its halves has five plates adjoining the adambulacrals and larger than the latter, so that one corresponds to two adambulacrals.

The second chevron has an impaired interradial plate, and each half has two plates; a second odd interradial lies opposite the median suture of the inferomarginals. These plates are not imbricated and each usually bears two small central spinules.

The adambulacral plates project into the groove and the inner edge bears a divergent row of three to five small spinules; on the actinal side they bear a somewhat oblique transverse row of two or three somewhat larger spinules.

The jaws are elongated, each half bears a large terminal or peroral spine and a row of four smaller graded adorals; also one enlarged epioral, inclined toward the mouth.

Blake Station 278, in 69 fathoms, off Barbados (3 specimens.)

This species seems to be nearest *Poraniella*, but the cotypes, which I have examined, are all evidently very young. Thus the

adult might be a *Porania* or some other related genus. I have seen only one type. It differs from the other similar small or young forms, in having more spines in the furrow-comb, as in *Poraniella.*

From *P. regularis* it differs especially in the form and arrangement of the dorsal plates. In the latter they are more numerous and show no tendency to form oblique rows running from the radials to the marginals, nor are the radial plates pentagonal, for their exposed edges are meniscoid or pelecoid. For the present, or until larger specimens can be found, I prefer to place this species under *Poraniella,* on account of its having the same arrangement of adambulacral spines and interactinal plates and spinules.

Genus Marginaster Perrier. (Type. *M. pectinatus*).

Marginaster Perrier, Bull. Mus. Comp. Zoöl., ix, p. 16, 1881; Etoiles de Mer, p. 229, 1884. Sladen, Voy. Chall., xxx, p. 364, 1889. Perrier, Exp. Trav. et Talism., p. 164, 1874.

Form pentagonal or stellate with short rays. Disk and rays a little convex, edges thin, bordered by a fringe of marginal spinules. Dorsal plates well developed, flatish, imbricated, covered with a thin integument, which often partially conceals the plates in alcoholic specimens; median radial row distinct. The larger plates usually bear few small spinules, often only one or two to a plate. Papulæ few isolated between the plates.

Upper and lower marginal plates distinct, about equal in number; the lower ones are larger and more prominent, and bear a terminal row of several spinules, forming a marginal fringe. Upper ones have fewer and smaller spinules, in a row in the type. Papular pores do not occur between the two rows of plates, in the type, but are present in some of the related species.

Interactinal plates few, rather flatish, imbricated or tesselated, arranged in short rows or chevrons, usually bearing one to three small clustered spinules. One or two plates are impaired between the jaws and the median interradial suture.

The adambulacral spines are small and in typical species form a short, transverse, usually oblique row of two to five spines; the two inner ones often stand nearly side by side. Jaw-plates relatively large, convex, separated by a median groove, and bor-

dered by a regular lateral row of several spines, and a pair of larger peroral spines.

Papular pores occur mostly singly over most of the dorsal surface of the rays and disk, and sometimes between the marginal plates. In *M. pectinatus*, the type, they are few and confined to the rays.

When first established by Perrier this genus included two very small unlike species (*M. pectinatus* and *M. echinulatus*) from the West Indies. The former should be the type. These were both incorrectly figured. Later (op cit., 1894) Perrier redescribed them in detail, and added a third. They are quite unlike, as shown by the original types, which I have examined, and may represent two diverse genera, owing to the different character of the adambulacral armature, for in the second species there is an inner longitudinal fan of three webbed spinules on each plate.

As in *Rhegaster* they may both be the young of other genera, such as *Porania*, etc. I have studied a considerable series of these and allied species, but they are all small and probably mostly quite immature. Therefore, the status of the type of the genus seems to me rather uncertain.

At present, it seems best to restrict the genus to those species, which, like the type, have a simple transverse row of adambulacral spines. Those that have an inner longtitudinal comb should be referred to *Poraniella*, or to *Rhegaster*.

Marginaster pectinatus Perrier.

Marginaster pectinatus Perrier, Bull. Mus. Comp. Zoöl., ix, p. 16, 1881. Nouv. Arch. du Mus., vi, p. 229, pl. i, figs. 4, 5, 1884. Exp. Sci., Trav. et Talism., p. 167, 1894, redescribed. Sladen, Voy. Chall., xxx, p. 366, 1889. Verrill, 1914*c*, p. 18.

The type of this species, which is preserved in alcohol in the Mus. Comp. Zoölogy, has been examined by me.

The adambulacral plates are small and crowded; each bears an inner or furrow-spine and one or two outer ones, there being but one of these distally, while on the middle part of the groove there may be two, or sometimes three spines, forming a small simple transverse row. These spines are all very small, slender, and crowded, most so near the middle of the rays.

The interactinal areas contain about ten to twelve plates,

which, when moist, are visible through the thin dermis that covers them. A few of them bear one, two, or sometimes three small clustered spinules.

The carinal radial row of plates is rather conspicuous; the plates are larger than those adjacent, irregularly four-lobed, overlapping by their lobes. Small, isolated, short, acute spinules are borne on most of the dorsal plates. The superomarginal plates of which there are six on a side, do not reach the margin; they bear only a few granule-like small spinules, as now preserved.

The inferomarginal plates project strongly beyond the margin; those in the middle of the interradial margin are decidedly larger than the others. The marginal fringe of spines, that they originally bore on each series, was mostly rubbed off before I first saw the specimen, in 1896, but Perrier (1894) states that there were four or five flat, lanceolate spinules on each plate of the lower series. His figure, however (1884), represents them as slender and acute. The figure is incorrect in various other respects.

According to the later description by Perrier (1894, p. 167), the type of this species has the following characters:

Radii 4^{mm} and 5^{mm}. The adambulacral plates bear one inner spine and another, or more often two, on the actinal side, a little larger than the inner one, divergent and placed one behind the other in a transverse row.

On the dorsal side the central, five radial, and five interradial plates are distinct. The basal radials are triangular with rounded corners, with the wider end turned proximally. The five carinals are imbricated and slightly cruciform, decreasing regularly distally. The ocular or terminal plate is semicircular and without spines.

The central plate has three spinules: the interradials six or seven; the basal radials three; the carinals two or one.

Transverse rows of smaller elliptical dorsolateral plates run from the carinals to the marginals. The first and second series have apparently, three plates; the third two plates; the fourth and fifth each have one unarmed plate. The larger of these plates bear two or sometimes three, small spines; the smaller only one spine. On the disk there are a few other plates irreg-

ularly placed. The papulæ are large, all dorsal, and arranged in rows.

The superomarginal plates correspond with the lower ones; each bears a marginal series of three or four flat, lanceolate spinules.

The inferomarginals are five on each side of a ray. They are rectangular, broader than long; each bears a marginal row of four or five flat, lanceolate, acute, hyaline spinules, forming a marginal fringe of spines.

The jaws are triangular, of moderate size, not prominent. Each half bears an angular peroral spine, four lateral spines, and two or three epiorals.

The interactinal plates form a triangular area; three larger ones stand in an impaired median row, running from the jaws to the median interradial suture; one small plate intervenes between the second interradial marginal plate and the third adambulacral, a larger plate lies between the third marginal and the fifth adambulacral. A series of three plates, the middle one alone well developed, runs from the suture between the first and second, and that of the sixth and seventh adambulacrals; the last plate lies between the sutures of the second and third marginals and that of the eighth and ninth adambulacrals. Some of these plates bear a single spinule; most are without spinules.

Perrier refers to the type specimen as ''unique'' (1884, p. 230, foot note). He states that it was accidentally irregular, which was the case in the type seen by me. The only locality given was the Blake Station 32, in 95 fathoms, N. lat. 23° 52′.

PORANIA (?) AUSTERA Verrill.

Marginaster austerus Verrill, Revision Genera Starfishes, Trans. Conn. Acad. Sci., vol. x, p. 221, 1899.

Porania ? austera Verrill, Ann. and Mag. Nat. History, vol. xiv, p. 20, 1914*c*.

Plate iii; figures 1—1*a*. Plate xi; figures 6—6*a*. Details.

Body flat below, swollen above, with short, thick, rapidly tapered acute rays. Radii of the type 11^{mm} and 17^{mm}; ratio, 1:1.6; marginal spines eleven. Whole surface covered with a rather thick dermis which conceals the outlines of all dorsal plates and most of the ventral ones, except the interactinals.

The dorsal surface is covered irregularly with small, short, blunt or clavate rough spines. These stand partly isolated, partly in little irregular rows of two to six. These rows run in various directions, but on the rays mostly obliquely or transversely to the ray, but without order. The concealed plates are irregularly lobed and reticulated, so as to leave rather large isolated papular pores, which are scattered over the whole dorsal surface, and also form a regular row between the two rows of marginal plates, where they are either single or two together. Madreporic plate, which is nearer the center than the margin, is small, oval, with fine gyri, and surrounded by small obtuse spines. Dorsal pore is small, surrounded by very small spinules.

The superomarginal plates are irregularly three-lobed or four-lobed, emarginate on both edges for papular pores. Each one bears about three or four small erect spinules like those around them, and irregularly placed.

Inferomarginal plates are prominent, beyond the upper ones, and form the margin. They have marginal notches between them. Each bears a horizontally projecting, single, outer marginal row of about five or six closely placed, slightly divergent, and only a little unequal, oblong, blunt spines. Above these, on the upper side, there is another row, corresponding in number, but not half so long, of small, acute spinules.

The under side of these plates, as seen through the thinner dermis, is transversely oblong, with the lateral margins slightly incurved, and with a small groove and marginal ridge at the inner end; the ridge may end in a slight tubercle at one or both ends. The rest of the surface is covered with minute rounded elevations.

The interactinal plates are easily visible, and mostly without spinules. They form oblique forked rows running from the marginals to the adambulacrals. The rows are separated by spaces covered only by the dermis, but the plates in each row are in close contact or slightly imbricated.

These rows or series of plates start from an angular plate opposite the suture between two inferomarginals. This is joined adorally by two (sometimes one) long-ovate, narrower plates, with the larger end centered; each of these is followed by two

similar but smaller plates, each of which abuts against two adambulacrals.

The two primary interradial rows start from an impaired plate, in line with the suture between the first marginals. Its two halves diverge rapidly, in a curve, leaving a small, nearly smooth and naked, triangular area outside the jaw-plates. A few irregular small plates are here concealed under the dermis. In the type two to three of the interactinal plates bear a single small blunt central spine, none have spinules.

The adambulacral plates are concealed by the dermis, which continues upward on the bases of the outer row of spines and forms a short continuous web between them.

Each adambulacral plate bears an inner small furrow-spine, and on the proximal part of the groove, mostly two larger, a little thicker, and somewhat flattened, oblong or slightly clavate blunt spines. Where not too crowded, these stand side by side, but they often stand more or less obliquely, and there may be but one on some plates. Near the distal end of the groove, they become more slender and more oblique, due to crowding. Near the jaw-plates a few plates may have two inner spines.

The adoral and peroral spines of the jaws are similar to those of the adambulacral plates, but slightly stouter, especially the apical ones. West Indies, special locality not known. (Coll. A. E. Verrill). Also taken by the Albatross.

This is probably immature, but I am unable to refer it to any described species.

Suborder Velata Perrier. (See above).

Family Pterasteridæ Perrier.

Pterasteridæ Perrier, op. cit., 1875; op. cit., 1884; op. cit. p. 180, 1894. Verrill, op. cit., 1899.

Pterasteridæ (*pars*) Sladen, Voy. Challenger, vol. xxx, p. 468, 1889.

Pterasteridæ Fisher, op. cit., 1911b, p. 343 Verrill, op. cit., 1914*a*, p. 266.

This is one of the most peculiar groups of starfishes hitherto discovered. It shows in general characters, a remarkably high degree of specialization not found in any other group. Most of the genera and species are from the deep sea.

Disk usually plump; rays 5-8, usually five, rarerly 6-9; upper

surface covered by a supradorsal membrane supported by the tips of long, slender, divergent, often webbed, paxillary spinules and pierced by small concentric pores or ''spiracles'' often closed and invisible in preserved specimens and usually with a central osculum. Beneath this membrane is a ''nidamental cavity'' or gonocodium, traversed by the columnar pseudopaxillæ, and containing the papulæ. In this cavity the eggs are retained, and also the young, till they assume the adult form, often 8 to 10^{mm} in diameter. The dorsal skeleton ossicles are lobed or cruciform, loosely reticulated.

The adambulacral spines usually form transverse webbed combs or fans (not much webbed in Hymenasterinæ).

Series of slender, divergent spines more or less appressed and attached to the under surface, or imbedded in it, and usually webbed to the adambulacral fans in Pterasterinæ, are always present. These peculiar spines, called ''actino-lateral spines'' by Sladen, should rather be called *retroambulacrals* or outer adambulacrals, for they are attached to the outer end of the adambulacral plates. They are sometimes short, and do not reach the margin, except distally, on the rays, but in *Pteraster* and some other genera their tips usually form the marginal edge of the disk.

Between the bases of these there is usually a small slit or pore (actinal spiracle or ''segmental aperture'') furnished with a partly calcareous valve. Interactinal plates are lacking. Pedicellariæ have not been found. Jaws have a series of adoral spines, usually webbed. Epioral spines of large size, in one to three pairs, often without webs, stand perpendicular to the jaw; those of one pair are sometimes specialized and partially hyaline. Ambulacral feet are large, in two to four rows, with large apical suckers.

The supradorsal membrane may be thin and translucent, with thin muscular fibres, or thick and muscular. In some cases it contains calcareous spicules, muscular and cartilaginous fibers in the form of a network, and often abundant mucous glands. The copious mucus is phosphorescent in some cases (*Diplopterasteer.*) The intestine and anal pore are well developed. Sexes are alike externally.

Subfamily HYMENASTERINÆ.

The genera *Hymenaster, Cryptaster* and their allies form a distinct subfamily, *Hymenasterinæ*, differing from *Pterasterinæ* in lacking webbed combs of adambulacral spines and in other characters. It is a characteristic deep-sea group. One or two species occur in the West Indies in deep water.

Subfamily PTERASTERINÆ. (See above).

Genus PTERASTER M. and Trosch.

Pteraster Müller and Troschel, Syst. Aster., p. 128, 1842. Type, *P. militaris.* Sladen, op. cit., p. 470, 1889. Fisher, op. cit., 1911*b*, p. 344, (Analytical table of all known species, pp. 368-370.) Perrier, op. cit., 1894, p. 181. Clark, op. cit., 1908, p. 286 (Analytical Table.) Verrill, op. cit., 1914*a*, p. 267.

Hexaster Perrier, Comptes-rendus, vol. 112, p. 1227, 1891. Type, *H. obscurus* Perrier.

Temnaster Verrill, Proc. U. S. Nat. Mus., vol. 17, p. 275, 1894. Type *T. hexactis* V. = *H. obscurus P.*

Disk large; rays 5 to 8; ambulacral grooves turn up distally, more or less reaching to the upper side of the rays.

Adambulacral spines form large, webbed combs. Retroambulacral or ''actinomarginal'' spines are closely appressed, ending in a fringe or fold. One pair of specialized epioral spines; these are often translucent distally. Supradorsal membrane furnished with a central contractile osculum, guarded by five or more groups of webbed, projecting spines. It usually contains irregular muscular or elastic fibers for its support and sometimes calcareous deposits. The muscular bands usually do not form a regular network and are generally very inconspicuous externally. Usually two rows of ambulacral sucker-feet.

PTERASTER CARIBBÆUS Perrier.

Pteraster militaris A. Agassiz, op. cit. (*non* Müller.)

Pteraster caribbœus Perrier, op. cit., 1881, p. 13; Etoiles de Mer, p. 216, 1884.

Plate vii; figure 4.

The radii of the type were 15^{mm} and 30^{mm}; ratio, 1:2. One before me has them 8^{mm} and 12^{mm}. The adambulacral comb of very slender hyaline, webbed spines contains six or seven erect spines, increasing in length outwardly, and another, the retro-

ambulacral, much larger and longer, recumbent, extending beyond the border of the ray and forming a webbed margin. The dorsal parapaxillæ, as seen below the supradorsal membrane, are mostly cross-shaped or four-lobed at the base, two of the lobes are often longer than the others, and somewhat enlarged distally. These lobes overlap and underlap those of the adjacent plates. From the center arises a very slender and rather long column, longer than the longest basal lobes, and about three or four times higher than thick. It is enlarged or subcapitate at the summit. Each bears about eight to ten long and very slender divergent, hyaline, webbed spinules, which enter and support the supradorsal membrane.

The jaws are prominent, subconical; each half has about six very slender marginal spines, becoming longer adorally.

The specialized epioral spine is relatively large, long, flatish, wider near the tip, or sublanceolate, nearly vitreous or translucent, and subhyaline in its distal half. It reflects prismatic colors in some lights.

The madreporic plate is hemispherical, raised on a stalk about as high as broad. The dorsal membrane is very thin and delicate and rises into many small conical or subacute angular elevations when dry.

This is a delicate and fragile species closely related to *P. militaris* of northern and arctic seas. Its supradorsal membrane is more delicate and its supporting parapaxillæ are longer and much more slender, with longer and more thread-like spinules.

This species was dredged by the Blake Exped. at four stations off Florida and among the Lesser Antilles, in 151 to 422 fathoms.

The Albatross dredged it at Station 2667, off Southern Georgia, N. lat. 30° 53′, in 273 fathoms (No. 18,415, described above.) It was not obtained by the Bahama Expedition.

Order Phanerozona Sladen (emended).

Phanerozona (emended) Sladen, Voyage Challenger, Zoöl., vol. xxx, Introd. pp. xxviii, xli, 1889. Verrill, Revision, Trans. Conn. Acad., x, p. 200, 1899. Fisher, op. cit., 1911*b*, p. 17. Verrill, op. cit., 1914*a*, p. 280.

Valvatæ + *Paxillosæ* (as orders), Perrier, in Mem. Etoiles de Mer, Antilles, etc., p. 154, 1884.

Valvata + *Paxillosa* Perrier, Exped. Trav. et Talism., pp. 22, 23, 28, 29, 1894; Resultats Camp. Scientif., Albert I, fasc. xi, p. 16, 1896.

This order includes starfishes varying in form from pentagonal to stellate, with long rays. They have two rows of large and thick marginal plates (rarely but one distinct row, as in *Luidia*), which are usually in contact and form a thick, nearly perpendicular margin. They are nearly always larger and thicker than the dorsal and actinal plates. Papular pores are nearly always confined to the upper surface and are usually placed singly, often in special areas. Dorsal skeleton various. The dorsal surface may be closely covered with angular tesselated plates, which may be naked, granulated, or covered with a smooth skin, or they may take the form of pseudopaxillæ, protopaxillæ or true paxillæ especially in the Paxillosa.

The various forms of paxilliform plates as distinguished in 1894, by the writer, are as follows:

True *paxillæ* are columnar or hour-glass-shaped ossicles, usually with isolated, circular or lobed bases, which bear at summit a group of small spinules, of which the marginal series are different from the rest and divergent, so as to cover the intervening spaces between the spines, thus forming fascioles or channels for the circulation of water to the papulæ. These are highly developed in *Astropecten* and *Luidia*. Those called *spinopaxillæ* are of the same general structure, but the center of the summit is occupied by a distinct spine, or by more than one. Such forms occur on some species of *Luidia, Pontaster*, etc.

Parapaxillæ are rounded or stellate ossicles, or angular plates, with a raised central portion, tabulate, truncate, or like a low cone. They may be either isolated or articulated by their bases. The summit is covered with small, differentiated spinules, like those of true paxillæ. Those on the dorsal surface of *Lophaster*, *Solaster*, and *Mediaster* are examples. They sometimes bear a central spine.

Protopaxillæ are similar, but less elevated, convex ossicles or plates, covered with round or angular granules, with the marginal series differentiated and more or less covering the grooves between the plates. As in the preceding, there may be a central spine in some cases. This form occurs on *Cheiraster*, many species of *Goniasteridæ*, etc. The transition from this last kind to simple, uniformly granulated plates is easy, when the grooves between the plates become obsolete.

Pseudopaxillæ are articulated plates with flattened, usually lobed, and often overlapping bases, which bear a group of slender, fascicled or divergent spinules on the more or less raised central or subcentral area or boss. These have no differentiated marginal series of spinules. This form is seen in *Henricia*, etc.

In some families the plates are reticulated ossicles, smooth or bearing large spines or tubercles as in *Oreasteridæ*. In other cases a thick skin may cover and obscure the plates.

The interactinal plates may be few in slender stellate forms or many in the pentagonal forms. In the latter cases they are usually arranged in definite rows, most often subparallel with the adambulacral plates, the latest formed ones being situated next the median, interradial, marginal plates, but they also form rows running from the adambulacral plates to the marginals, and often define fasciolated grooves.

They are most commonly tesselated and granulated, or else in the form of pseudopaxillæ or protopaxillæ; but they are sometimes spinose. They may be more or less imbricated by their edges or lobes.

Adambulacral plates are not compressed, rather large, usually oblong or quadrangular, and commonly bear numerous small spines, various in arrangement.

Ambulacral plates are rather large, not compressed nor crowded. Ambulacral feet are in two rows, with terminal suckers in *Valvulosa*; but in the *Paxillosa* they are large and pointed, without distinct suckers.

Pedicellariæ are sometimes lacking, but usually present and sometimes large. They may be bivalved, sessile, and seated over a pore (foraminate), or implanted in special pits on the plates (fossate); or else papilliform or fasciculate, composed of two to four or more modified, convergent spinules; or pectinate, consisting of two comb-like groups of spinules convergent over a suture between two adjacent plates, as in *Luidiaster*, or seated on a single plate.

The sessile valvular pedicellariæ with a pore between the valves are called *foraminate*; they may have two, or more than two, valves (*bivalvular* and *trivalvular*, etc.). In the suborder *Valvulosa* they are often provided with a pair of pits or fossæ, into which the valves fit when widely open. The valves in these

are often spatulate, spoon-shaped, or suger-tongs shaped, or battledore-shaped, and usually may best be called *plataleiform* or *spatulate*. When furnished with receiving pits, they have been called *excavate*; but *fossate* seems to be a more appropriate term.

The peculiar papilliform pedicellariæ of the *Paxillosa*, with two to four or more slender valves, apparently formed by modified spinules or granules, are also found in certain of the *Valvulosa*. Sometimes such pedicellariæ are found associated with larger valvular pedicellariæ on the same specimen, as in the genus *Nymphaster*, and in a few other genera.

The following is the arrangement of the suborders and families adopted by the writer (op. cit., 1914*a*):

Order PHANEROZONA.

Suborder I. VALVULOSA Verrill = VALVATA Perrier.
(Sense extended.)

Family I. OPHIDIASTERIDÆ Verrill, 1867 = LINCKIADÆ Perrier, 1875.
Family II. VALVASTERIDÆ Fisher, 1911.
Family III. ASTEROPIDÆ Fisher, 1911 = GYMNATERIDÆ (*pars*) of authors.
Family IV. OREASTERIDÆ Fisher = *Pentacerotidæ* Gray (restricted).
Family V. MIMASTERIDÆ Verrill.
Family VI. GONIASTERIDÆ Forbes (restricted), includes *Antheneidæ* Perrier (restricted).
Family VII. ODONTASTERIDÆ Verrill = *Gnathasterinæ* Perrier (*pars*).
Family VIII. CHÆTASTERIDÆ Ludwig.
Family IX. ARCHASTERIDÆ Ver. (restricted to *Archaster*).

Suborder II. NOTOMYOTA Ludwig (as an order).

Family X. BENTHOPECTINIDÆ Verrill; *Benthopectininæ* Verrill, 1894.

Suborder III. PAXILLOSA Perrier (sense restricted).

Family XI. PORCELLANASTERIDÆ Sladen.
Family XII. GONIOPECTINIDÆ Verrill.
Family XIII. ASTROPECTINIDÆ Gray (restricted).
Family XIV. LUIDIIDÆ Verrill = *Luidiinæ* Sladen.

All these families, except Nos. ii, iii, v, and ix are represented in the West Indian area, but some of them occur only in deep water.

Subfamilies of Goniasteridæ.

Subfamily I. Goniasterinæ Verrill = *Pentagonasterinæ* Sladen (*pars*).
Subfamily II. Pseudarchasterinæ Sladen.
Subfamily III. Mediasterinæ Verrill.
Subfamily IV. Nectriinæ Per.; Fisher.
Subfamily V. Hippasteriinæ Verrill.
Subfamily VI. Antheneinæ Fisher (sense restricted).
Subfamily VII. Leptogonasterinæ Perrier.
Subfamily VIII. Chitonasterinæ Fisher.

Those subfamilies represented in the West Indian shallow-water fauna are the first, third and seventh. But the seventh is essentially a deep-sea group; only a few stray examples occurring in less than 150 fathoms. The third and fifth families are well represented in the deeper waters. The others are chiefly extralimital.

Suborder Valvulosa Verrill.

Valvulatæ (order) Perrier, Nouv. Arch. Mus. Hist. Nat., vi, 1885.
Valvata (order) Perrier, Exped. Trav. et Talism., pp. 22, 23, 28, 29, 1894.
Valvata (suborder) Verrill, Revision, Trans. Conn. Acad., x, p. 200, 1899.
Valvulosa Verrill, North Pacific Starfishes, p. 284, 1914*a*.

These starfishes are stellate or pentagonal and usually rather stiff in appearance, and are nearly always five-rayed. The dorsal plates are most commonly tesselated and granulated, or else take on the character of protopaxillæ or pseudopaxillæ. Owing to the generally close union of the plates, especially of the large marginal plates, most of these starfishes are rather rigid, showing much less flexibility than in most other groups. The *Ophidiasteridæ* are exceptional in this respect, for they are mostly flexible in life.

Ambulacral feet are large, with well developed suckers.

Pedicellariæ are often lacking; when present they are usually valvular, foraminate and sessile, or fossate. The valves may be either granuliform, or large and broad, or narrow and spoon-

shaped, plataleiform, spatulate, or battledore-shaped, rarely papilliform. There may be two to five valves. The valvular form of the pedicellariæ first led to the establishment of this group.

The various kinds of dorsal plates pass into each other by various intermediate forms, so that it is impossible to draw any very strong or sharp family lines on this character alone, though the character of the plating may generally be taken as of generic value. They are more frequently polygonal and tesselated; often in the form of protopaxillæ or parapaxillæ; sometimes deeply lobed and openly reticulated; sometimes imbricated.

Sometimes they are naked; often spinose; very rarely truly paxilliform; sometimes covered by a thick, smooth, or granulated integument.

Both rows of marginal plates are usually well developed and form a stout margin to the disk and rays.

Interactinal plates are usually rather numerous and tesselated or imbricated. A distinct dorsal pore is usually present. Genital pores are generally ten, usually all separate, situated in the dorsal interradial areas; sometimes serial on the sides of the rays.

Superambulacral plates are present in some genera, absent in others. The existence of superambulacral plates, formerly supposed to be characteristic of *Astropectinidæ*, occurs in several of the genera now referred to *Valvulosa* (viz., *Mediaster, Dytaster, Pseudarchaster*, etc.), and in other groups.

Adambulacral plates wide, with a longitudinal group of small furrow-spines and with one or several spines on the actinal side, often becoming much longer distally. Jaw-plates are large and usually convex on the actinal surface, bearing numerous oral and epioral spines.

This is a very extensive group, found in all seas.

Family OPHIDIASTERIDÆ Verrill.

Ophidiasteridæ Verrill, Trans. Conn. Acad. Sci., i, part 2, p. 344, 1867; op. cit., p. 308, 1914*a*.

Linckiadæ Perrier, Revision Stellerides, p. 117 [381], 1875.

Linckiidæ Sladen (*pars*), op. cit., 1889, p. 397. Fisher, op. cit., 1911*b*, p. 240.

Linckiadæ Viguier, Squelette des Stell., p. 144, pl. ix, figs. 1-13; pl. x, figs. 1-7, 14-19 (structure), 1879.

Form stellate, usually with five slender, flexible rays, but the number is variable in some autotomous species.

Abactinal and marginal plates usually tesselated or subimbricated, in rows or irregular; in most cases granulose (covered with rather thick, smooth skin in *Leiaster*), sometimes tuberculated, rarely spinose.

Marginal plates are usually well developed, in two regular rows, but often not conspicuous and rarely so thickened as to form a rigid margin. They are similar to the dorsal plates, as to granulation.

Papulæ usually numerous, mostly abactinal and lateral and in groups, sometimes single; in some of the genera they occur also between or below the marginals, or between the interactinal plates.

Adambulacral plates small, covered with either granules or spinules, the margin bearing one or two rows of small spines, no more.

Pedicellariæ often lacking; when present, usually bivalve, sometimes spatulate and fossate. Superambulacral plates often present.

Genus Ophidiaster Agassiz (restricted).

Ophidiaster (*pars*) L. Agassiz, Prod. Monog., 1834. Gray, op. cit., 1840, p. 283; Synopsis, 1866. Müll. and Trosch. (*pars*), Syst., p. 28, 1842.
Ophidiaster (emended) Lütken, op. cit., p. 163, 1864. Perrier, Revision, p. 384, 1875; op. cit., 1884, p. 221 (descr.)
Linckia (*pars*) Nardo, 1834. Von Martens, op. cit., p. 351, 1865.

Disk small; rays slender, subterete, closely granulated. The dorsal plates are in about three to five regular rows, leaving squarish or angular papular areas between them in regular rows. Papular areas sometimes occur, also, between the marginal rows; rarely, also, in one submarginal row. The marginal plates, which form two regular rows, are not unlike the dorsals, and closely granulated. Interactinals are smaller, angular, and usually form one or two narrow rows. Adambulacral plates usually have two unequal small spines on the inner edge, and one just back of them in the second series decidedly larger, stout, but not much elongated. Superambulacrals are usually present but small. Fossate pedicellariæ, usually with spatulate valves, occur on most species.

Ophidiaster guildingii Gray.

Ophidiaster guildingii Gray, op. cit., 1840, p. 284; Synopsis, p. 13, 1866 (description inadequate). Perrier, Revision, p. 387, 1875 (no description). Lütken, op. cit., 1871.

Scytaster mülleri Duchassaing, Ann. Rad. des Antilles, 1850 (t. Perrier from types.)

Ophidiaster flaccidus Lütken, Vidensk, Meddel., p. 86, 1859 (good description.)

Rays five, with a weak skeleton, roundish, slender. Radii of a medium sized specimen 5^{mm} and 60^{mm}; ratio 1:12. Other specimens have shorter rays. The dorsal and lateral surfaces are covered with about nine rows of plates, between which there are eight equally spaced and pretty regular rows of large papular areas, each with about five to twelve papular pores. There is no median area destitute of papulæ. Marginal plates are much like the dorsals. All these plates are covered with small, unequal, squammiform granules, some of them minute.

The adambulacral plates bear two rows of small obtuse spinules; those of the inner or furrow series are small, equal, and crowded; those in the adjacent outer row are decidedly larger, about half as numerous, with some granules between their bases.

The color, in life, commonly varies from orange-red, with irregular yellow markings, to purplish brown, with blotches of dirty white (Clark).

Lütken (op. cit., 1871) recognized that his *O. flaccidus* is the same as *O. guildingii* Gray.

Locality of Gray's types was unknown. Perrier, who examined the types, states that they are identical with *O. flaccidus*.

St. Thomas (Lütken; Perrier). Fort Reef, Port Antonio, Jamaica (Clark.)

Ophidiaster floridæ Perrier.

Ophidiaster floriadæ Perrier, op. cit., 1881, p. 9; Mem. Etoiles de Mer, p. 221, pl. iv, fig. 1.

This was described from a single young specimen (radii 5 and 33^{mm}) from off Florida, in 20½ fathoms.

It is, perhaps, the young of *O. guildingii*, the common shallow water West Indian species.

According to Perrier it is formed much like a *Linckia*. The dorsal and marginal plates form seven regular rows of elongated

oval plates, covered with a granulation much like that of the actinal side. The plates are rather prominent and distinct.

No papulæ are found below the inferomarginal plates; between the marginal and dorsal rows there are six regular rows of papular areas, each having two to four pores.

The disk has ten distinct radial and interradial plates.

Interactinal plates are smaller than the marginals, arranged in few regular rows, without papulæ between them, but defined by the rather large rounded granules that closely and regularly cover them.

The adambulacral plates bear two contiguous rows of spines; those of the inner marginal row are small, regular, and equal; in the outer row each group has a much larger, obtuse median spine and a small flat one each side of it.

On the interradial areas are two rows of interactinal plates that bear spines similar to those of the outer adambulacral spines but smaller; some of them bear fossate pedicellariæ, having spatulate valves. The second row is, however, in the young specimen, feebly developed with few plates.

Straits of Florida, in 123 feet (Perrier, Coll. Mus. Comp. Zoöl.). Probably 123 fathoms was intended. Off E. Florida, 277 fathoms, Albatross collection.

OPHIDIASTER ALEXANDRI Verrill, sp. nov.

Plate xiii; figures 3, 3*a*, 3*b*. Details. Plate xxv; figure 2. Type.

Disk small, rays regularly tapered, subacute. Radii of the type 11^{mm} and 60^{mm}; ratio, 1:5.5. The upper and lateral surfaces of the rays have five very regular and nearly equal rows of somewhat prominent plates, closely united radially, but so openly and regularly united transversely as to leave nearly square papular areas, which form very regular rows. They contain about eight to ten pores.

The disk is somewhat convex. It has a set of basal radial and interradial plates, and a central, larger than those of the rays, and a little swollen.

The madreporic plate is large, round, flat, covered with fine radiating gyri. The whole surface of the plates and the papular areas is covered with a fine even granulation, above and below.

The interactinal rows of plates, beneath, are so closely united and densely granulated that their outlines are not visible without preparation. When denuded they are seen to form three rows. The three plates in a transverse series are imbricated. These plates are ovate, except the one next to the adambulacral plate, which is truncated at the suture, and corresponds in width and position to the adambulacral that it joins. Two transverse series correspond to one inferomarginal. The latter are much larger and four-lobed.

The small transversely oblong adambulacral plates are finely granulated and bear a simple row of very small and short, flat, blunt marginal spinelets, two to a plate; and an outer row of much larger and longer, stout, tapered spines, alternating with very small acute spinelets, one of each kind on each plate.

Dredged by the Bahama Expedition at stations 56 and 57 on the Pourtales Plateau, off Florida, in 200 to 225 fathoms. Taken by the Albatross at station 2416 in 276 fathoms, coral sand and shells, N. lat. 31° 26′, off Georgia, several specimens. (Nat. Mus.; Yale Mus.)

Perrier (1884, p. 172, and 1894, p. 37) listed an undescribed species of this family as "*Fromia mexicana*" from station 207, off Martinique, in 96 fathoms. This seems not to have ever been described, and is to be regarded as a MSS. name.

Genus Linckia Nardo.

Linckia Nardo, Okens Isis, 1834, p. 717. Gray, op. cit., 1840, p. 284; Synopsis, p. 13, 1866. Lütken, Vidensk. Meddel., pp. 163, 164, 1864 (emended); op. cit., p. 266, 1871. Viguier, Arch. Zoöl. Exper. et Gen., vol. vii, p. 147, pl. x, figs. 1-6 (structure), 1878. Verrill, op. cit., 1867, p 285; op. cit., p. 309, 1914*a*. Perrier, op. cit., p. 399, 1875; Etoiles des Mer, p. 226, 1884. Sladen, op. cit., vol. xxx, p. 408, 1889. Fisher, 1911*b*, p. 242.

Ophidiaster (*pars*) Müller and Troschel, Syst. Ast., p. 28, 1842.

Disk small; rays long, slender, nearly terete, usually five, variable in number in some autotomous species. Adambulacral plates bear granule-like structures, in two or three close series, those in the second row alternately larger. Pedicellariæ not observed. Two madreporites in autotomous species.

Interactinal plates usually form two or more close rows. Dorsal plates are irregularly arranged, not forming definite

radial rows; closely granulated. Papulæ are numerous, in clusters on the dorsal side, but are lacking below the marginal plates.

LINCKIA NODOSA Perrier.

Linckia nodosa Perrier, Revision, p. 417, 1875; Etoiles des Mer, p. 226, 1884. Sladen, Voy. Chall., pp. 409, 786, 1889. Fisher, op. cit., 1906, p. 1088.

Plate xiii; figures 2—2*a*. Plate xxix; figures 1*a*, 1b.

The type of this species had the radii 11^{mm} and 91^{mm}; ratio, 1:8.3.

The dorsal plates form about three irregular crowded rows; some of these plates, irregularly disposed, are larger and more convex than the others, or even subnodose; similar swollen plates also occur upon the disk.

The papular areas are small and well defined; they mostly have six to eight pores; fewer on the disk. Madreporic plate large, flat, with numerous fine, sinuous gyri.

The marginal plates are squarish, covered with granules a little smaller than those of the interactinal plates; between the two rows are roundish papular areas, with about twelve pores.

There are several rows of interactinal plates proximally, the inner ones short; the outer or peractinal row extends nearly or quite to the tip of the rays. These plates are all covered with small rounded granules, those near the adambulacral plates are a little the larger.

The adambulacral spines are almost granuliform; they form two rows; those of the margin of the groove are alternately larger and smaller; the larger are clavate, the smaller cylindric. Close to these are the spines of the outer row; each of these is opposite one of the smaller spines of the inner row; they are rather larger than the larger of the inner row. External to these spines is a row of granules larger than those of adjacent plates and also some intermediate small granules. There are no actinal papular pores.

A larger specimen before me was taken by the Albatross off Pensacola, Fla. The radii are 13^{mm} and 125^{mm}; ratio, 1:9.6.

The rays are well rounded above, flattened below, and taper very gradually.

The dorsal surface of the rays is covered with a broad, very irregular band of large, swollen, evenly convex, unequal, roundish plates, mostly in contact radially to a variable extent. These, where most regular, seem referable to three rows, by reason of the large, irregular papular areas between them. The plates that seem to belong to the median row average larger and more prominent than the others, but are unequal and seem to be crowded out of position by the growth of others.

Outside of those described, and on the sides of the ray, there is a much more regular row of dorsolateral plates, which are also roundish and strongly convex, but less so than those above. They are in serial contact, but are joined to the row above by small connective ossicles and large intervening papular areas, which form here a regular row. The papulæ are small and very numerous in these and the dorsal groups. Twenty to thirty or more can be counted.

All these plates, as well as those below, are covered closely with small, nearly uniform rounded granules, which also surround the papular pores, but there become angular, so that four or five around each pore look like small valves.

The two rows of marginal plates are very distinct and nearly equal and regular. Their plates are less convex and not so large, about five corresponding to four in the row above. They are broadly in contact serially, but the two rows are separated by a regular row of large papular areas, like those above.

Below the inferomarginals and closely joined to them and to each other there are three or four rows of squarish interactinal plates, so closely united and compactly granulated that their outlines are concealed. Their granules gradually become coarser and angular near the adambulacral spines.

The adambulacral plates are small and concealed by granules. Each bears two unequal inner erect spines; both are flattened and obtuse. The larger is more than twice as large as the other, but only a little higher. Outside these, but close to them, and alternating with them, is a single larger, obtuse, flattened, erect spine, about twice as large as the larger inner ones, and about as broad as high. These, like the inner ones, form a regular continuous row, very distinct from the adjacent granules.

These rows continue to the jaw plates with but slight change,

but three or four of the most proximal ones of the outer row, and especially the first, become larger, higher and more obtuse, and stand a little farther back from the inner row, the first pair becoming the epioral spines on the small jaws. The inner spines on these few proximal plates also become a little more elongated. About eight somewhat more slender spines in a continuous row, form the peroral armature of the angle of the combined jaw plates.

The granules in the adoral area are larger and higher than elsewhere.

The ocular plate is small, roundish or broad-ovate, convex or mammiform, not bilobed and not granulated. It is turned upward.

The madreporic plate is large, situated below the basal interradial plate and nearly fills the space between two large basal radials, one of which it joins. It is covered with very numerous fine, even, radiating and bifurcating gyri.

The disk is covered with a group of large, unequal, very convex rounded plates, like the radial plates adjacent. Ten of the larger of these can be referred to the basal radial and interradial plates. These enclose an irregular group of about five larger and several smaller plates. The diameter of the larger plates is about 4^{mm}; of the madreporic plate, 5^{mm}.

I have also examined a young specimen in the Museum of Comparative Zoölogy, labeled as this species by Perrier, and taken by the Blake, at station 100, off Moro Light, Cuba, in 250-400 fathoms.

This agrees well with larger specimens, of medium size, taken near the same place by the Bahama Expedition, but its adambulacral spines are relately smaller, and less differentiated from the adjacent coarser granules. The granules of the inferomarginal plates are more unequal, there being two or three rows of distinctly larger ones on the otherwise evenly granulated surface.

These characters seem to be due to the immaturity of this specimen. The dorsal plates are also relately less swollen than in the larger examples.

It was dredged by the Albatross, in 130 fathoms, off West Florida, and in 21 fathoms, off Pensacola (large specimen de-

scribed above); also, by the Blake, off Moro Light, in 250-400 fathoms; off Tortuga I., Antilles, in 6 fathoms.

The Bahama Expedition took it at station 3, off Havana, in 110 fathoms. The locality of the type was not known. According to Bell, it also occurs in Torres Strait. Probably this is an error.

LINCKIA GUILDINGII Gray.

Linckia guildingii Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 285, 1840; Synopsis, p. 14, 1866. Perrier, Revision, op. cit., vol. iv, p. 408, 1875. Sladen, op. cit., p. 410, 1889. A. Agassiz, North Amer. Starfishes, p. 105, pl. xiv, figs. 1-6, 1877. (Details of structure.) Verrill, Trans. Conn. Acad., vol. xi, p. 36, 1901; vol. xii, p. 281, pl. xxxiv, c, fig., 1907; (In The Bermuda Islands, Part v, p. 281 (325), 1901. R. Rathbun, Brazilian Echinod., p. 148, 1879.

Ophidiaster ornithopus Müll. and Troschel, Syst. Aster., p. 31, 1842 (t. Perrier from types). Lütken, op. cit., p. 80, 1859. Duj. et Hupé, op. cit., p. 361, 1862.

Linckia ornithopus Verrill, Geog. Distribution Echinod., Trans. Conn. Acad. Sci., vol. i, p. 344, 1867; op. cit., vol. i, p. 367, 1868.

Linckia ornithopus Lütken, op. cit., p. 80, 1859; pp. 266, 270, 271, 1871.

Scytaster stella Duch., op. cit., p. 4, 1850 (t. Perrier from type.)

Plate xxviii; figure 3.

The rays are long, slender, well rounded in life. They are often unequal and vary in number; most frequently they are five or six, sometimes four or seven, due to autotomous division. The dorsal plates in this species are numerous, thick, somewhat convex, irregularly polygonal, and closely crowded, often overlapping by their edges, mostly without connective ossicles, except very small ones laterally. They are like all the rest of the plates, above and below, thickly covered with fine granules. The papular areas between them are small, with few papulæ.

The marginal plates are rather larger than the dorsals, more quadrangular, and form two nearly equal, regular rows.

There are usually, in adults, at least two long regular rows and some shorter ones of much smaller, squarish interactinal plates, and also a small triangular interradial group. These are covered and obscured by the crowded granulation.

Adambulacral plates bear two rows of small, short spinules, and there is also, especially proximally, a row of similar spines

on the adjacent series of interambulacral plates, parallel to the outer row, so that they resemble a third row of interambulacral spines. These interactinal spines agree in number and stand opposite to the outer interambulacral spines.

There are usually two madreporic plates in those specimens that divide by autotomy. Specimens with any number of rays from one to five are to be found. Those in the "comet-form," due to autotomy or injury, are not uncommon.

The types of *O. ornithopus* (M. and Tr.) were from Vera Cruz; those of *S. stella* were from Guadeloupe.

Perrier (1875) stated that he had examined these types and found them identical with *L. guildingii*, as well as with authentic specimens from the Cape Verde Islands. Gray's type was from St. Vincent Island.

On the American side this species occurs at the Bermudas, Florida Keys, Bahamas, Vera Cruz, throughout the West Indies, and south to Bahia, Pernambuco, and the Abrolhos Reefs, Brazil. Cape Verde Islands (Perrier and others). The Yale Museum has it from Pernambuco, Brazil (coll. C. F. Hartt, No. 4557), and the comet form from the Abrolhos Reefs (coll. Hartt, No. 1583).

Genus Narcissia Gray.

Narcissia Gray, op. cit., p. 287, 1840; p. 15, 1866. Sladen, op. cit., pp. 398, 413, 1859. Perrier, Exped. Trav. et Talisman, pp. 329, 330, 1894.

Ophidiasteridæ with serially arranged radial plates, the median and two marginal rows larger; all granulated. Papulæ stand singly or in pairs between the plates. Adambulacral plates have three longitudinal series of short, thick spines, often prismatic.

Narcissia trigonaria Sladen.

Narcissia trigonaria Sladen, op. cit., p. 414, pl. lxv, figs. 5-8, 1889.

Rays rather long, triquetral, with a strong median radial keel composed of large, somewhat swollen plates; margins rounded with well developed, convex, marginal plates in both series, about thirty-seven in the type. All the plates are covered with minute, uniform granules. Papulæ stand singly between the plates, or in pairs.

The adambulacral plates have three series of short, thick, subprismatic spines, about four in each series, those of the outer one much smaller.

Off Bahia, Brazil (Sladen). Specimens from off West Florida, in 25 and 26 fathoms (Nos. 18,454-6, Nat. Mus.) appear to belong to this species.

Family OREASTERIDÆ Fisher.

Pentacerotidæ (*pars*) Gray, 1840 and 1866. Perrier (*pars*), 1884, 1894. Sladen, op. cit., p. 342, 1889; and of many other writers.
Goniasteridæ (*pars*) Verrill, 1867. Perrier (*pars*), 1875.
Oreasteridæ Fisher, op. cit., 1911*b*, p. 18. Verrill, op. cit., p. 282, 1914*a*.

Large phanerozonate starfishes which have a large, thick, massive, cushion-like or angulated disk and stout rays. The dorsal areas are large, supported by a reticulated skeleton, leaving large papular areas, containing great numbers of small papular pores, confined to the dorsal surface. The dorsal plates are largely oblong or bar-like, and often have a stellate arrangement. The plates are more or less obscured by a thick granulose dermis.

The marginal plates are relatively small and inconspicuous, granulated, and covered by dermis. Like the dorsal plates they may also bear large conical spines.

The interactinal areas are large, covered with thick, tesselated plates, bearing coarse granules, small bivalve pedicellariæ, and often one or more stout central spines. Adambulacral plates have a marginal series of spinules, and one or more thick spines on the actinal surface.

Besides the genus *Oreaster*, this family includes *Culcita*,[17]

[17] The arctic starfish described by Süssbach and Breckner (Seeigel. Seest. Schlang. N. und Ostsee, p. 217, pl. i, figs. 4-6, 1910) as *Culcita borealis*, does not belong to this genus nor to the same family. It seems to be generically most nearly related to a large deep-sea form from our northern waters, having a thick dermis and partly aborted dorsal skeleton described by me as *Chondraster grandis* (op. cit., 1895, p. 137), formerly as *Porania grandis* (*pars*), op. cit., 1878, p. 371.

In this arctic, so-called *Culcita*, the body is even more swollen and cushion-like, due to a still more rudimentary skeleton, but I see no reasons for separating it from Poraniidæ, with which it agrees in other respects. Therefore I have proposed for it a new genus, *Culcitopsis*, with *C. borealis* for its type. See also Verrill, 1914*c*, p. 21.

which is confined to the Indo-Pacific ocean, and several other Pacific genera.

Genus OREASTER Müller and Troschel.

Pentaceros Linck, De Stellis Marinis, p. 21, 1733 (not binomial). Schülze, Betracht. der Verstein. Seesterne, p. 50, 1760, *t.* Sladen (not binomial). Schröter, Mus. Gottwald. Testac. Stell. mar., etc., p. 58, Nürnberg, 1782, *t.* Sladen (not binomial).

Pentaceros Gray, Ann. and Mag. Nat. Hist., vi, p. 276, 1840. Synopsis, p. 6, 1866. Perrier, Revis. Stell., v, p. 52 [236], 1876. Agassiz, A., North Amer. Starfishes, p. 108, pl. xvi, figs. 1-7 (structure), 1877. Viguier, Archiv. Zoöl. Exper. et Gen., vii, p. 193, pl. xi, figs. 4-6, pl. xii, figs. 3, 4, 8-11 (structure), 1878. Sladen, Voy. Chall., xxx, p. 343, 1889. Perrier, Exp. Trav. et Talism., p. 406, 1894.

Goniaster (*pars*) L. Agassiz, Prodr., p. 191, 1835.

Oreaster Müll. and Troschel, Syst. der Aster., p. 44, 1842. Von Martens, Ostasiat. Echinod., p. 81, 1866. Lütken, Vidensk. Meddel., 1859, p. 63; op. cit., 1864, p. 161 [39]. Verrill, Trans. Conn. Acad. Sci., i, pp. 278, 343, 1867; op. cit., p. 367, 1868. Perrier, Pedicellaires, p. 69, 1869.

This genus includes many large, massive, tropical starfishes, with a large and usually high, swollen, angular disk and rather rigid-looking rays.

The dorsal plates are thick, stellate-reticulated, leaving large papular areas between them, with many small papulæ. The plates are always granulated and some or all often bear large spines or tubercles.

The marginal plates are paired, but not very large, and partly concealed by the thick granulose dermis. The inferomarginals are often confined to the lower side, the superomarginals forming the border. Those of each series may bear stout conical spines or tubercles.

The interactinal plates are numerous on the disk and are usually closely tesselated, bearing granules and conical spines. Strong internal interradial septa containing large calcareous plates support the disk.

The adambulacral plates bear, each, a longitudinal row of two to four or more rather small spines on the inner margin and one or several much larger and thicker spines on the actinal surface.

Pedicellariæ are often numerous, bivalve, usually small, or about equal to the granules among which they are scattered.

OREASTER RETICULATUS (L.) M. and Trosch.

Asterias reticulata (*pars*) Linn., Syst. Nat., ed. x, p. 661, 1758. Retzius, op. cit., 1783; Diss., p. 14, 1805. Lamarck, Ann. sans Vert., vol. ii, p. 556, 1816.

Oreaster reticulatus M. and Trosch., Syst. Aster., p. 45, pl. iii, fig. 2, 1842.

Pentaceros reticulatus with *P. grandis* and *P. gibbus* Gray, Ann. and Mag., vol. vi, p. 277, 1840, and Synopsis, p. 6, 1866.

Pentaceros reticulatus A. Agassiz, North Amer. Starfishes, p. 108, pl. xvi, figs. 1 to 7 (details of structure), 1877. Viguier, Nouv. Arch. Zoöl. Exper. et Gen., vol. vii, p. 193, pl. xi, figs. 4-6; pl. xii, figs. 3, 4 (structure), 1878. Nutting, Narrative Bahama Exp., pp. 52, 187, 202, 212 (colors).

Asterias gigas Linn., Mus. Tessinianum, p. 114, pl. ix, 1753.

Oreaster gigas Lütken, op. cit., p. 64, 1859. Verrill, op. cit., i, p. 367, 1867. R. Rathbun, op. cit., p. 149, 1879.

O. lepidosus Grube and *O. tuberosus* Behm are additional synonyms (t. Lütken). Also *A. sebæ* Blainville. *O. aculeatus* Gray is the young (t. Perrier).

A very large massive species, having a broad, thick or high swollen disk, usually with interradial contractions, in dry specimens, corresponding to the attachment of the stout calcareous, internal, interradial septa.

Radii of a fair-sized specimen are 90^{mm} and 200^{mm}; ratio, 1:2.22. Much larger specimens occur, up to 500^{mm} or more in diameter. Many have shorter rays.

The dorsal plates have a very distinctly stellate-reticulate arrangement. The median radial row is distinct. Their portions imperfectly visible at the surface are narrow and at their nodes there is nearly always a short, stout, conical spine, both on the rays and disk. The median radial ones are a little larger. The whole surface, between the spines, is closely covered with small unequal granules mingled with small bivalve pedicellariæ of similar size. The granules also extend up on the bases of the spines, ending in a definite ring or border of short, angular, flat or truncate granules. All the granules are minutely roughened.

The papular areas are very large, with great numbers of single papulæ.

The upper marginal plates are not large; about 20 to 22 occur on each side of each ray, in mature specimens. They form the margin of the disk, but their outlines are obscured by the thick

covering of granulose dermis and two to four short, thick, conical spines that each one usually bears. Their granules are rather coarse, unequal, polygonal, and closely packed. Intermingled with the granules are small bivalve pedicellariæ of sizes similar to the adjacent granules.

The inferomarginal plates are similar in size, and are confined to the actinal side, except close to the tips of the rays. They are granulated in the same way as the upper ones, and each usually bears a cluster of three to five or more short conical spines, the larger ones smaller than those of the superomarginals and quite similar to those of the interactinal plates.

The interactinal plates are numerous, forming large areas, extending well out on the rays. They are arranged in simple divergent rows, the first rows subparallel to the adambulacral plates, but also forming single oblique rows, each one corresponding to a single adambulacral plate, but two usually corresponding to a single inferomarginal plate. They and their sutures are covered with large granules and bivalve pedicellariæ coarser than those on the dorsal side, and each usually bears also a central group of two, three, or more, short, stout, blunt, unequal spines.

Their pedicellariæ mostly have an ovate or elliptical basal raised cup, which encloses the basal part of the two wide and short valves. They are larger than those of the dorsal side, with relatively wide valves.

The adambulacral plates have a marginal series, usually of three or four, small, flat or angular blunt spines, and the actinal side bears one or two short, stout, conical spines, surrounded by coarse granules and many raised bivalve pedicellariæ.

The ambulacral feet are large and strong, with large suckers.

The colors, in life, are various, and seem to differ in different localities. According to Nutting its colors in the Bahamas are often deep red relieved by the bright yellow color of the spines. "Others were various shades of red, deepening into a rich maroon, alternating with orange and yellow" (op. cit., p. 53). According to A. H. Verrill those that he saw at Samana Bay, San Domingo, were green or greenish in color, while those that he saw at Dominica Island were yellow or orange-yellow, varying to yellowish brown. According to Clark (op. cit., p. 5, 1898) it is "orange-red of some shade" in Kingston harbor, Jamaica,

where it is plentiful. When dried it usually becomes deep terra-cotta color or brown.

In life it is more flexible than its appearance would indicate. Nutting states that it can curve its rays above its back until the tips touch.

This is the largest and most massive West Indian starfish and also one of the most common in shallow water. It has a wide range, extending from South Carolina to the Abrolhos Reefs, Brazil, and to the Cape Verde Islands. It is very common in the Bahamas, where large numbers were obtained by the Bahama Expedition, and about the Florida reefs and keys, as well as throughout the West Indies. Abundant at Bahia and Pernambuco, low tide to two fathoms, and at the Abrolhos Reefs (R. Rathbun). South Carolina (Agassiz).

Family Goniasteridæ (Forbes), emended Verrill.

Goniasteridæ (*pars*) Forbes, 1840. Verrill, Trans. Conn. Acad. Sci., i, p. 343, 1867. Perrier (*pars*), Revision, Arch. Zoöl. Exper. et Gen., iv, pp. 281, 283, 289, 291, 1875; op. cit., v, p. 1, 1876.

Pentagonasterinæ Viguier (*pars*), subfamily, op. cit., vii, p. 166, pl. x, figs. 20-25, 1878.

Pentagonasteridæ (*pars*) Perrier, op. cit., p. 231, 1884. Sladen (*pars*), op. cit., pp. 260, 264, 1889.

Goniasteridæ Verrill (restricted), Revision, in Trans. Conn. Acad. Sci., x, p. 145, 1899 (*non* Viguier). Fisher, op. cit., 1911*b*, p. 158. Verrill, op. cit., 1914*a*., pp. 281, 285, 286.

Phanerozonate starfishes usually having a rather broad flat or slightly convex, rather rigid disk, sometimes nearly pentagonal in form, but often stellate with more or less prolonged rays. Marginal plates usually large and thick, forming a thick, nearly vertical margin, the two rows equal or subequal.

Dorsal plates are various, but usually tesselated, polygonal, or roundish, sometimes lobed or substellate, united directly or by internal ossicles. They are commonly granulated or protopaxilliform, sometimes spinulose, or they may bear tubercles or spines; rarely naked, or covered with soft skin, with or without granules.

Interactinal plates usually numerous, angular, tesselated, or imbricated. Superambulacral plates may be present or absent. Tube-feet are in two rows and have suckers.

Pedicellariæ usually present, often large, usually bivalve, but may be multivalve, foraminate, often fossate. They may occur on any of the plates, or on the thick skin that covers them in some genera (*Anthena*, etc.).

This is a very extensive family, found in all seas, with numerous genera. Many of the genera are found only in the deeper waters.

It may be divided into several subfamilies. See above.

Subfamily GONIASTERINÆ.

Genus GONIASTER (Agassiz), Gray (restr.). Type, *G. cuspidatus*.

Goniaster (*pars*) Agassiz, Prod. Mem. Soc. Neufch., 1836.

Goniaster Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 280, 1840. Type *G. cuspidatus*; Synopsis, p. 10, 1866 (*non* Perrier, 1876, *nec* Sladen, 1889).

Pentagonaster (*pars*) Perrier, Revis., Arch. de Zoöl., v, p. 24, 1876. Sladen, Voy. Chall., xxx, p. 264, 1889.

Astrogonium (*pars*) Müll. and Trosch., Syst., pp. 52, 56, 1842.

Phaneraster Perrier, Exp. Sci. Trav. and Talisman, pp. 334, 337, 387, 1894. (Type *G. semilunatus* = *cuspidatus*.)

Goniaster Verrill, Revision Genera, p. 150, 1899. Fischer, op. cit., 1911*b*, p. 167. Verrill, 1914*a*, p. 286.

The form is stellate-pentagonal, or stellate with a broad disk and short rays.

The dorsal plates are large, polygonal or roundish, covered with crowded, short, angular granules, with a larger marginal series; sometimes they also bear pedicellariæ. Between these there are often, in adults, many small ossicles, usually bearing groups of few granules. Papular pores are present between most of the abactinal plates, except in the small interradial areas.

One or more large, stout, conical tubercles or spines occur on more or less of the dorsal margins and abactinal plates, in adult specimens; or verruciform swellings, in the same situations, in the young. In most adults these conical spines form a central group on the disk and five large radial groups, but the number of plates that bear spines is variable; sometimes they occur on nearly all the dorsal plates.

The marginal plates are large, thick, convex, not numerous, and usually naked, except for one or two marginal series of granules, but they are more or less granulous over the surface in the very young. They are more numerous in the ventral series. The

distal inferomarginals sometimes bear small conical spines or tubercles. Those in the dorsal series may not decrease regularly distally; the last one is sometimes as large as, or even larger than, the one that precedes it. The apical plate is small, conical.

The adambulacral spinules are numerous and closely crowded in three or more rows; the row next to the furrow series is largest. They grade into the spinulation of the interradial areas.

The interactinal plates are large, polygonal, and crowded, mostly in series parallel with the adambulacral plates, and covered with coarse granules; the granules on the center of the plates are often larger and may be like small tubercles. Sometimes a few bear conical spines.

Pedicellariæ may occur on the dorsal, marginal, and interactinal plates, and they sometimes occur, also, on the sides of the dorsal spines. They are fossate, small, high, slender, pincer-shaped, with spatulate blades and corresponding fossæ on the plates. They are often entirely lacking.

When very young (up to 12 or 14^{mm} in diameter) there is no appearance of dorsal spines or tubercles and the marginal plates are few in number and granulated.

This genus is found in all the great oceans, in warm latitudes, and in shallow water or at moderate depths. The Indo-Pacific species (*G. cuspidatus*) the type of the genus, has a very wide distribution.

GONIASTER AMERICANUS Verrill.

Goniaster americanus Verrill, Amer. Journ. Sci., vol. ii, p. 230, 1871 (full description).

Pentagonaster semilunatus (*pars*) Perrier, Arch. de Zoöl. exper., v, p. 24, 1876.

Phaneraster semilunatus (*pars*) Perrier, Sci. Exp. Trav. et Talis., p. 388, 1894.

Pentagonaster parvus Perrier, Mem. Etoiles de Mer, Nouv. Archives du Mus. d'Hist. Nat., vi, p. 231, pl. vii, figs. 7, 8, 1884. (Young.)

Goniaster americanus Verrill, Revision Genera, pp. 151-156, pl. xxiv*a*, figs. 1, 2 (type); pl. xxvi, figs. 1-6, 1899.

Plate xiii; figures 5, 5*a*.

The type had short rays and a broad disk; radii 35^{mm} and 62^{mm}; ratio, 1:1.8. In this there are usually six superomarginal plates and seven inferomarginals on each side of a ray, but this

number varies from less than three up to nine or more, on a side, according to age. The largest number counted by me was 19 in one interradial arc on a specimen with radii 35^{mm} and 65^{mm}.

The type has numerous conical dorsal spines, for they occur on nearly all the radial and disk plates, but not on the marginals, though some of these are swollen or somewhat tubercular. In the type the penultimate superomarginal is a little larger than those that precede it, but in others, equally large, they decrease regularly in size. One or two distal pairs are usually in contact medially.

The dorsal plates are rather large, polygonal, with regular granules. Most of them, except on small interradial areas and near the tip of rays, are surrounded by numerous (10 to 12) simple papular pores. Proximally, in adults there are, also, small, interpolated, granulated plates between the larger radial plates and between the papulæ.

On each of the distal adambulacral plates there is a single large, obtuse conical spine, outside the furrow-series of slender spinules. These spines are longer and larger than the more numerous corresponding spines of the more proximal plates. There are usually, in large specimens like the type, four stout, prismatic, blunt, crowded spinules on each plate, in the furrow-series.

This type specimen (Museum of Yale University) has a large number of high, pincer-like fossate pedicellariæ, with two slender spatulate or spoon-shaped blades, and a slightly enlarged articulating base; the blades are sometimes straight, but often more or less strongly curved to the right or left. The blades, when fully expanded, rest in socket-like depressions of the plates, which correspond in shape and curvature with the blades, so that the two belonging to a pedicellaria with curved blades, form, when taken together, a crescent-shaped or semicircular fossa, with a round central pore and a wider rounded depression at each end. Sometimes one or two granules exist close to the pedicellariæ, and when rubbed off the pits that they leave make the markings on the plates more complex.

Pedicellariæ of this form are present on a large proportion of the interactinal plates; on some of the marginal plates; on the borders of the spiniferous dorsal plates, around the bases of the

spines, 1 to 6 on a plate; on the basal part of the spine itself; and on those dorsal plates that do not bear spines, 1 to 4 or more.

On the interactinal plates they are variously placed and irregularly oriented; most of the plates have but one, which is most commonly near the center, but many have two; those plates in the row next to the adambulacral plates usually have two or three. The pedicellariæ on the dorsal plates and on the spines are smaller than those of the lower surface, but have the same form and similar fossæ. Each pedicellaria of the interactinal and dorsal plates occupies a small, slightly elevated, smooth, rounded or ovate area, surrounded by granules. A pedicellaria and a stout blunt tubercle co-exist on some of the interactinal plates, near the jaws. Many specimens are destitute of pedicellariæ.

Some specimens have large, stout spines on several of the interactinal plates, near the jaws.

The distal superomarginal plates of some large specimens bear large, acute, conical spines. In other cases they bear lower obtuse spines, or mere tubercles. The number of rows of large radial spines is variable and also the number in a row. They may be higher and more acute than in the type, and much fewer in number.

The number in the principal radial rows varies from three to six, in the larger examples. Sometimes there are only eight to ten large spines on the dorsal side, irregularly placed.

I have examined four young specimens of this species from the Blake Exp., preserved in the Museum of Comparative Zoölogy.

Three of these were types of *Pentagonaster parvus* Perrier. They agree perfectly with those of similar size collected by the steamer Albatross in the West Indies. With the latter they form a complete series, connecting the smallest with the full grown examples from the same region.

The specimens next to the smallest in size are 25 to 35^{mm} in diameter (types of *P. parvus*) and usually have six marginal plates on each side, above and below. In the smaller of these the upper and lower marginal plates and the interactinal interradial plates are nearly or quite covered with small granules, but in the somewhat larger specimens more or less of the central area of these plates is naked. Most of them show a distinct central

swelling where the conical tubercles would have appeared later. In some the dorsal plates are entirely covered with granules, but in others the central area is naked, the amount of naked surface increasing with age, but not regularly so. The papular pores increase in number with age and cover more and more of the median radial areas and the central area of the disk, but these areas have no sharp boundaries.

The type was from off South Carolina, in rather shallow water. This species was taken by the Albatross at twelve or more stations in the West Indian region, in 21 to 50 fathoms, and by the Blake at three stations, in 84 to 129 fathoms (all young).

This, or an allied species, has been recorded from Brazil, under the names *G. cuspidatus* or *G. semilunatus*, which properly belong to the Indo-Pacific species. I have seen no Brazilian specimens.

Several variations (Nos. A-H), due largely to age, have been described by the writer. (See Revision Genera, pp. 151-155, 1899.) Details of the distribution are also given in that article.

Plinthaster dentatus (Per.) Fisher.

Pyrenaster dentatus (Per., p. 242, 1884). Verrill, 1899, p. 167 = *Plinthaster dentatus* Fisher, 1911b, p. 165. (Notes on type.)

This species was recorded by Perrier (1884, pp. 170, 242), as from Blake stations, Nos. 100, 111, 260, in 250 to 1,500 fathoms, and by me (1899) from 478 to 1,639 fathoms.

Also recorded by Perrier from Blake station 264, in 41 fathoms. It is evidently a deep-sea species, of a deep-sea group. This last record is typographically erroneous, Blake station 264 was in 416 fathoms, gray ooze off Grenada. Perrier (1884) gives the depth correctly on page 180. (Table of localities, but erroneously in other places in the same report.)

Subfamily MEDIASTERINÆ Verrill.

Mediasterinæ Verrill, Revision Genera, p. 178, 1899; op. cit., 1914*a*, p. 294.

This subfamily was proposed in 1899, for *Mediaster* and several allied genera, closely related to *Goniasterinæ*, but having the dorsal plates in the form of parapaxillæ, besides other characters.

Since its establishment large numbers of related new genera and species have been discovered by several deep-sea explora-

tions, which serve to unite the two subfamilies very closely. Therefore it is now hard to draw the line between them.

It may be just as well to abandon the subfamily and unite the genera under Goniasterinæ, as Professor Fisher (1911*b*) has already done.

As there is but a single species, within my present limits, that can be referred with certainty to the *Mediasterinæ*, it is not my intention to discuss the question at this time, and therefore I now retain the group chiefly as a matter of convenience.

Genius Mediaster Stimpson.

Mediaster Stimpson, Journ. Boston Soc. Nat. Hist., vol. vi, p. 490, pl. 23, figs. 7-11, 1857. Type M. *æqualis* Stimp.

Mediaster Sladen, Voy. Challenger, Zool., vol. xxx, pp. 263, 752, 1899. Verrill, Revision Genera, p. 178, 1899. Fisher, op. cit., 1911*b*, p. 196. Verrill, op. cit., 1914*a*, p. 295.

Isaster Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 257, 1894. Type *M. bairdii* Ver.

Form stellate, with a broad flat disk and moderately long tapered rays.

The dorsal plates or parapaxillæ are regularly arranged in radial rows, of moderate size, somewhat elevated in the center, mostly roundish, covered with a rosette of short, obtuse spinules or granules. When these are removed the plates on the central part of the disk and along the median region of the rays appear as roundish or oval convex bosses. They are connected together by five or six internal radiating ossicles, between which are the pores for the papulæ. Thus the plates appear to be stellate at the base, though they are not actually of that shape. In a limited interradial area the plates are closely joined and tesselated. The median row of dorsal plates extends to the apical plate of the rays in the type, but not in some of the other species. Some of the plates bear a central, broad, sessile, valvular pedicellaria, which, in the type species, is nearly as wide as the plate. They are sometimes lacking. The papulæ may be single, or (as in the type) clustered.

Marginal plates are well developed, not swollen, granulated, rather numerous, higher than broad, paired, upper and lower series nearly equal in size and number, and with their sutures

more or less closely corresponding vertically; oblique in the type. No odd interradial plate.

The adambulacral plates bear a regular marginal row of three to seven slender spinules, and usually two exterior longitudinal groups or rows of shorter spinules, which may be angular and obtuse, and toward the tips of the rays, some of them, in the type, become larger and longer. Some of these spinules may be replaced by spinuliform or clavate, two or three-bladed pedicellariæ.

The interactinal plates are angular, often rhombic, closely arranged in rows subparallel with the ambulacral grooves, covered with a rosette of granules, the central granules often replaced by a wide valvular pedicellaria. The dentary plates are not very prominent. Small superambulacral plates are present in all the species dissected.

MEDIASTER (?) PEDICELLARIS (Perrier) Verrill.

Goniodiscus pedicellaris Perrier, op. cit., 1881*b*, p. 23; Nouv. Arch. du Mus., vi, p. 245, pl. iv, fig. 3, 1884. Sladen, op. cit., p. 756, 1889.

Mediaster (?) *pedicellaris* Verrill, Revision Genera, p. 183, 1899. Fisher, 1911*b*, p. 197.

One of the types of Perrier, in the Museum of Comp. Zoölogy, examined by me, had the following characters:

The radii are 18^{mm} and 59^{mm}; ratio, 1:3.3. Dorsal plates, large, roundish, the summit convex when naked, but flat when covered with the spinules; the largest have about sixteen marginal, tapered, acute spinules, and one to five or more somewhat larger, acute, central ones. Intervening papular pores large, single, about six around each plate, except that there is none between the plates in the median radial rows; a row on each outer border of the abactinal area extends nearly to the end of the rays, or to within about ten marginal plates of the end.

The median series of plates extends about four or five plates farther than the lateral, but ceases within four or five plates of the tip; from thence the marginal plates are in contact.

Superomarginal plates bevelled and covered with small, sharp, spaced spinules; the upper spinules are shorter than the lower ones, larger, stouter, acute, divergent; those around the margins are similar and do not form regular fascioles.

Inferomarginal plates large, roundish, with one or two marginal series of sharp, divergent, stout spinules, and a central larger one. Sometimes there are three to five central spinules on the dorsal plates and on the row of plates next to the adoral plates. Pedicellariæ small, narrow, elevated, spatulate in form and rather numerous on the dorsal side.

Station 295, Blake Exped., 115 to 180 fathoms. This species was also taken by the Albatross in the West Indies.

This species, for lack of duplicate specimens, has not been dissected to ascertain the presence of dorsal connective ossicles, and therefore it is referred to *Mediaster* with some doubt.

Mediaster (?) *agassizii* Verrill, op. cit., 1899, p. 181.

This species was also taken in the West Indies by the Blake Expedition, but the locality and depth are unknown.

Genus Rosaster Perrier.

Pentagonaster (*pars*) Perrier, op. cit., p. 22, 1881; Etoiles de Mer, p. 238, 1894.

Rosaster Perrier, Exped. Trav. et Talisman, p. 386, 1894. Verrill, Revision Genera, p. 197, 1899. Fisher, op. cit., 1911*b*, p. 164.

Stellate with slender rays and large disk, marginal plates large, regularly paired, covered with spinules; no spines on dorsals.

It has rounded, columnar, paxilliform abactinal plates (parapaxillæ), covered, like the marginal and interactinal plates, with small spinules. Most of the superomarginal plates of the rays are in contact medially.

The inferomarginal plates are spinulose and agree in number, position, and nearly in form with the dorsals. Interactinal plates are thick, closely arranged in two or more chevrons on the triangular interradial area; each row has an impaired median plate; they are spinulose.

Adambulacral plates do not have a prominent inner angle. They bear a straight furrow-series of four or five slender spines, and on the actinal surface two or three larger erect spines, which form a regular row. Superambulacral plates are small. Fossate pedicellariæ with spatulate valves are often present on the dorsal plates; smaller erect ones sometimes occur on the marginal and adambulacral plates.

The paxilliform dorsal plates are thick and have slightly lobed bases (usually six lobes); they are united by these lobes, without intermediate ossicles, and have isolated papular pores in the intervening spaces; the median radial row is distinct but like the others. On the disk the five interradial primary plates are much larger than the others, round, tabulate, and spinulose.

The marginal plates are separated by deep ciliated grooves, but are not fasciolated.

Only one species of the genus is known.

Rosaster alexandri Perrier.

Pentagonaster alexandri Perrier, Bull. Mus. Comp. Zoöl., ix, p. 22, 1881. Nouv. Arch. du Mus., vi, p. 238, pl. vi, figs. 3-8, 1884.

Rosaster alexandri Per., Exp. Sci. Trav. et Talism., Echinod., p. 387, 1894. Verrill, Revision Genera and Species of Starfishes, p. 197, 1899.

Plate xi; figures 3—3*b*, details. Plate xvii; figure 2.

Form small, stellate, with a large disk, incurved sides, and rays tapering to slender tips. Radii of a specimen taken off Havana, by the Bahama Expedition, 7^{mm} and 15^{mm}; ratio, 1:2.12; marginal plates nine, large.

The six superomarginal plates that form the evenly incurved margin of the disk are distinctly larger than those on the rays; they are wider than long, convex, and rise above the paxillar area, forming a stout border. Those on the rays are at first rectangular but decrease rapidly in size and become square. Seven pairs are in contact medially. Ocular plate is broad ovate, not notched above. The marginal plates are covered with spaced small, short, rough spinules, smaller and acute above, larger and more obtuse or clavate on the outer side and along the margins of the sutures, which have deep grooves, but are not fascioled.

The dorsal paxillar area is pentagonal, not extending beyond the basal radial plates. The radial areas are covered with regularly stellate parapaxillæ, which have a thick six-lobed base and a short cylindric, or slightly tabulate, central boss or column, surmounted by a divergent stellate group of about eight to ten short slender spinules, surrounding a larger, slightly spiniform central one. The spinules are very regularly arranged, and are minutely thorny at the tips. In each of the intervals between the basal lobes there is a papular pore. In the interradial area

there is a small group of seven to ten more irregular plates, closely joined and without intervening papulæ. On the radial areas there is a median row of parapaxillæ, not differing from those adjacent.

Around the center of the disk there are five interradial, round, tabulate parapaxillæ, more than twice as large as the others and covered with similar rough spinules of which there may be sixteen to eighteen marginal and ten to twelve in a central group.

The small convex madreporic plate is attached to the outer edge of one of these plates, which are united to five smaller radial plates; within these there is a group of six plates of which one is central and a little larger than the others, which are like the radials, and have intervening papular pores. No dorsal pore is ordinarily visible.

The inferomarginal plates agree closely with the upper ones in size, form, ciliated grooves and spinulation, and stand exactly opposite them. The interactinal plates are few relatively large, thick, slightly lobed within, and are closely united or else slightly overlap by their edges. They bear small, upright, rough, acute spinules, six to eight surrounding a central one on the larger plates. These plates form a continuous row of nine next the adambulacrals with the impaired plate next the jaws. In the second row there are about five small plates, with the median one impaired.

The adambulacral plates are small, short, rectangular, two of them about correspond to one of the larger interactinals; and three distally to one marginal. Their inner margin is very straight and bears an even row of four or five very slender subequal spines, which completely interlock across the narrow groove. On their actinal surface they have two upright, longer and somewhat larger acute spines, side by side; on the adoral plates these became decidedly larger and longer. On a few of the adambulacral plates there is an upright small two-valved, spatulate pedicellaria.

No pedicellariæ were found on the upper side of this specimen, but on some others a few of the dorsal plates have one or sometimes two, fossate pedicellariæ with spatulate valves.

It was taken by the Bahama Expedition on the crinoid ground, off Havana, in about 200 fathoms.

It was taken at several stations by the Blake, in 84 to 1930 fathoms; and by the Albatross at a number of stations in the West Indies and Gulf of Mexico, in 98 to 980 fathoms. A number of specimens were taken, off Havana, on the cinoid grounds in 98 to 201 fathoms.

Subfamily Leptogonasterinæ Perrier.

Genus Anthenoides Perrier.

Anthenoides Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 23, 1881; Etoiles de Mer, p. 246, 1884. Verrill, Revision of Genera, p. 173, 1889. Fisher, op. cit., p. 173, 1911*b*.

Disk broad with regularly incurved borders and rapidly tapering rays, becoming slender distally. Both series of marginal plates are well developed, opposite, paired, and form a stout border to the disk and rays. Radius of disk is equal to about ten proximinal marginals.

Dorsal plates are polygonal or slightly lobed, nearly equal, pretty closely joined in mosaic, with small papulæ between them. The median radial row is distinct. There are few or no secondary plates except next the radial rows.

All the plates, above and below, are covered with a thin smooth dermis, partly concealing the plates.

All the marginal, interactinal, and dorsal plates are more or less granulated, beneath the dermis.

The inferomarginal plates have one or more larger granules, tubercles, or small spines on the outer end; in the larger specimens forming a row of spinules.

Interactinal plates form a large area, extending to about midlength of the ray. They are polygonal and closely joined. Those next the adambulacral plates and near the jaws mostly bear a bivalve pedicellaria with short valves.

The adambulacral plates have an inner regular row of several (5-8) small spines, and an actinal row of two or three larger ones.

Anthenoides peircei Perrier.

Anthenoides peircei Perrier, op. cit., p. 23, 1881; Etoiles de Mer, p. 247, pl. viii, fig. 1, 1884; Comptes rendus, 1889, p. 60. A. Agassiz, Three Cruises Blake, vol. ii, p. 103, fig. 379, 1888.

Anthenoides (?) Nutting, Narrative, p. 169, figure 1, 1895.

Plate iii; figure 2. Young. Plate x; figures 1-1*b*, 2-2*f*. Details.

Disk broad more or less swollen; with evenly incurved margins, bordered by rather large, stout, marginal plates, and covered with numerous pretty regularly arranged polygonal plates, which form the median radial rows. Rays rapidly tapered becoming slender distally, bordered by smaller convex plates, which are in contact distally. All these plates are finely granulated beneath a thin dermis that covers them, but does not entirely conceal their outlines.

The type of Perrier had the radii 32^{mm} and 80^{mm}; ratio, 1:2.5. It had about 27 marginal plates, on each radial side. He mentioned others of larger size. One had the radii 53^{mm} and 156^{mm}. Another had them 33^{mm} and 131^{mm}. These were from 151 to 150 fathoms. One taken by the Bahama Expedition had the larger radius about 62^{mm}; diameter 125^{mm}, or about five inches.

The inferomarginal plates, in the larger specimens, have a marginal row of several small spines, or even more than one row, on the interradial plates, when they become larger.

Sometimes there is a ridge or line of coarser granules along the superomarginal plates, on large specimens.

The interactinal plates are numerous, extending to middle of rays. They are polygonal, closely joined, granulated, and with a thin outer dermis. Those next the jaws and adjacent to the adambulacral plates bear a low, bivalve pedicellaria.

The adambulacral plates have a furrow-series of about six to eight small graded spines, the largest in the middle; on the actinal side there is another row of about three larger and shorter spines. Very young specimens of this species have an appearance quite unlike the adults, and may be mistaken for some other species.[18]

This was taken by the Bahama Expedition on the Pourtales Plateau, in 80 fathoms ("five inches in diameter"). Young ones were taken in 60 fathoms, off Key West, station 26. It was dredged by the Blake in 151 fathoms off St. Lucia; in 150 fathoms, off Guadeloupe; 85 and 82 fathoms, off Barbados; 73 fathoms, station 290, off Barbados (young); and at station 266, in

[18] In the Blake collection some young from station 243, in 82 fathoms were labelled "*Dorigona bifurcata* Perrier, MSS.," but other similar specimens were correctly identified and labelled by Perrier.

461 fathoms, off Granada (very young). The bottom at these stations was sand and shells or gray sand, except that in 85 fathoms, which was "hard."

Family CHÆTASTERIDÆ Ludwig.

Chætasterinæ (subfamily of Linckiadæ) Sladen, Voy. Chall., xxx, pp. xxxv, 397, 1889. Perrier, Exp. Trav. et Talism., p. 328, 1894.

Linckiadæ (*pars*) Viguier, op. cit., vol. vii, p. 147, 1878. Perrier, op. cit., 1884, p. 164.

Chætasteridæ (family) Ludwig, op. cit., 1899. Fisher, op. cit., 1911*b*, pp. 18, 21.

Stellate starfishes with elongated well rounded rays and small disk. Dorsal and marginal plates similar in several definite rows, elevated in the middle and bearing slender, divergent paxilliform spinules; some plates may be larger and nodulous. Internally they have radiating connective ossicles. Papular pores dorsal, mostly isolated, none intermarginal. Adambulacral plates have a marginal row of slender spinules and a group of small ones on the actinal side. Ampullæ single. Odd interradial marginal plates may be present. Interradial septa calcified. Pedicellariæ unknown.

Genus CHÆTASTER M. and Trosch. (emended), type, *C. subulata.*

Chætaster (*pars*) M. and Tr., 1840, p. 321. Syst. Ast., p. 27, 1842. Perrier, Revis. Stell., Arch. Zoöl. Exper. et Gen., v, p. 249, 1876 (not described). Viguier, Arch. Zoöl. Exper., vii, p. 152, pl. x, figs. 8-13, 1878 (structure).

Chætaster Sladen, op. cit., vol. xxx, pp. 397, 398, 399, 1889.

Nepanthia (*pars*) Gray, 1840, p. 287; Synopsis, p. 15, 1866.

Chætaster Fisher, op. cit., 1911*b*, pp. 18, 20, 21.

Characters are included in the description of the family.[19] It is the only genus. Very few species are known.

The type species is *C. longipes* (Retz.) = *Asterias subulata* Lam., found in the Mediterranean and East Atlantic, off the Azores, etc., and ranging down to 1100 meters or more.

[19] The position of this family is uncertain. The character of the plates and spinulation is much like those of *Henricia,* of the Echinasteridæ. It agrees with that family in having simple ampullæ.

CHÆTASTER NODOSUS Perrier.

Chætaster nodosus Perrier, Arch. Zoöl. Exper., v, p. 250, 1876. Sladen, Voy. Chall., xxx, pp. 398, 399, 778, 1889.
Chætaster longipes (*pars*) Sladen, op. cit., p. 399, 1889.

Plate viii; figures 1, 2. Plate xiii; figures 4, 4*a*. Details.

Rays five, nearly terete, long, slender, regularly tapered to unusually slender tips and bearing large, scattered, tubercular plates. Disk small, margins rounded. Radii of one 10^{mm} and 74^{mm}; ratio, 1:7.3; of another, 9^{mm} and 76^{mm}; ratio, 1:8.5.

The dorsal and lateral surfaces of the rays are covered with eleven radial rows of plates, five on each side and one carinal or median, the latter similar in size and form to those adjacent.

The lower ones, on each side, are smaller and their rows cease at about the middle of the rays; near the tips there are but five rows. These plates have an expanded base and an elevated central portion, which is smaller, transversely elliptical, nearly flat on the top, which is covered by numerous small, slender and delicate hyaline spinules; those around the margin are longer, very slender and when perfect interlock across the spaces intervening between the plates. They break off easily at the base and then the plates appear granulated.

The larger tubercle-like plates are often three to five times larger than the others, and much more elevated; they are round or elliptical, convex, and covered with very numerous small slender, rough spinules, those on the middle shorter. These large nodular plates are irregularly distributed and differ in number on the several rays; the number is often twenty to twenty-five. They occur both on the median and lateral radial rows of plates, but not on the disk in our examples.

Papular pores of rather large size occur singly, in rows between all the dorsal and dorso-lateral rows of plates except next the marginals. There are about two to each plate.

The two regular rows of marginal plates are situated well down on the ventral side. They are larger than the adjacent lateral plates, thick, transversally oblong proximally, becoming squarish and then rounded distally, convex and covered like the dorsals with very numerous slender, minute, rough spinules,

which form a very regular marginal fringe, but they are shorter than those of the dorsals. The interspaces between these plates and between the two rows are narrower than those of the dorsal surface and contain no papular pores. The two rows are much alike, but the lower ones are larger.

The adambulacral plates are similar in form, about one-fourth as large, two of them corresponding to one inferomarginal. Each one bears a crowded group of slender, rough, hyaline spinules on the actinal surface, and a crowded furrow-series of four to six somewhat larger ones. Within the outline of the disk these spines, and also those of the actinal side, become much longer and setiform.

There is a small triangular group of interactinal plates, spinulated much like the dorsals, with rough hyaline spinelets.

The dorsal plates of the disk are rounded, smaller than those of the rays, but spinulated in the same way. The madreporite is small and covered with similar spinules.

Taken by the Bahama Expedition at station 16, of Havana in 200 fathoms, (specimen described above), and at station 7, off Havana, 140 fathoms, one specimen. The type was from off Guadeloupe.

The tuberculated specimens taken off Bermuda, in 30 fathoms, by the Challenger and referred to *C. longipes* by Sladen, belong apparently to this species.

CHÆTASTER LONGIPES Sladen (?).

Chætaster longipes Sars, op. cit., p. 107, 1857. Sladen, op. cit., p. 399, 1859 (not described). Perrier, op. cit., p. 329, 1894 (not described).
Asterias longipes Retzius, Diss. Aster., p. 20, 1805.
Asterias subulata Lamarck, op. cit., p. 568, 1816.
Chætaster subulatus Müll. and Troschel, op. cit., p. 27, 1842.

Sladen states that his Bermuda specimen is young, and has some nodosites, which recall those of *C. nodosus* Perrier.

Probably it was a young specimen of the latter, which occurs off Florida in similar depths. *C. longipes* is a Mediterranean species, ranging to the Azores.

Off Bermudas, in 30 fathoms, and off Fayal, Azores, in 450 fathoms (Sladen), East Atlantic, in 102 to 1139 meters (Perrier.)

Family Odontasteridæ Verrill.

Gnathasterinæ (*pars*) Perrier, Exp. Trav. et Talism., pp. 244, 251, 1894.
Odontasteridæ Verrill, Revision Genera and Species of Starfishes, p. 201, 1899. Fisher, op. cit., 1911*b*, pp. 18, 153. Verrill, op. cit., 1914*a*, p. 302.

Form either pentagonal or stellate with a broad disk. Marginal plates well-developed in both series.

Jaws, each with a single, recurved, more or less hyaline median spine, or with two such spines, side by side. In the latter case one of these spines arises from near the apex of each oral plate. Both conditions sometimes occur, abnormally, on the same specimen.

An odd interradial marginal plate, above and below, on each side.

The marginal plates are covered either with spinules or granules; sometimes the upper ones are granulated and the lower spinulose, like the corresponding disk-plates; they usually have deep fasciolated sutures.

Abactinal surface covered with more or less paxilliform plates, parapaxillæ or protopaxillæ, with intervening large papular pores on the radial areas.

Interactinal plates angular, covered either with spines or granules. Small simple pedicellariæ sometimes occur on the interactinal or abactinal plates. They may have two, three, or four papilliform blades.

Adambulacral plates usually bear elongated spinules arranged in three or four pairs of small transverse rows, generally only two or three of the furrow-series are on each plate; sometimes only one. Oral plates usually have elongated, acute marginal and apical spines. They are sometimes closely united along the median suture; in other cases (*Odontaster*), they are separated by a space covered only by membrane.

Genus Odontaster Verrill.

Odontaster Verrill, Amer. Journ. Science, xx, p. 402, 1880. Proc. U. S. Nat. Mus., xvii, p. 262, 1894. Amer. Journ. Sci., xlix, p. 136, 1897.
Gnathaster Sladen (*pars*), Voy. Challenger, vol. xxx, Asteroidea, p. 285, 1889. Perrier (*pars*), Exp. Trav. et Talism., p. 244, 1894.
Odontaster Bell (*pars*), Proc. Zoöl. Soc., London, p. 260, 1893. Verrill, Revision Genera and Species of Starfishes, p. 205, 1899. Fisher, op. cit., 1911*b*, p. 154. Verrill, op. cit., 1914*a*, p. 303.

Form stellate, with a wide disk and short rays.

A single, odd, hyaline, recurved movable spine is on the apex of each jaw. The oral plates are large, partly separated by an open fusiform space covered by membrane. Abactinal surface covered with elevated, convex or clavate paxilliform plates, or parapaxillæ, which usually bear clusters of elongated spinules, like true paxillæ; their bases are stellate. The upper marginal plates are usually finely spinulated.

The adambulacral plates usually bear several rows of spines, usually three or four in the furrow-series, rarely but two.

The odd interradial marginal plate is usually triangular or wedge-shaped. Simple pedicellariæ occur rarely.

The radial abactinal plates form more or less evident obliquely transverse rows and some extend nearly or quite to the apical plate.

Papular pores are generally large and placed singly in the angles around the radial parapaxillæ.

The inferomarginal plates and interactinal plates are covered with acute, more or less elongated spinules.

ODONTASTER HISPIDUS Verrill.

Odontaster hispidus Verrill, Amer. Journ. Sci., vol. xx, p. 402, 1880. Proc. U. S. Nat. Mus., vol. xvii, p. 263, 1894. Amer. Journ. Sci., vol. xlix, p. 136, 1895; Verrill, Revision Genera and Species of Starfishes, p. 205, pl. xxix, figs. 8, 8*a*, 1899.

Plate xiii; figure 6.

Form depressed, stellate, with a rather broad disk. Radii vary in proportion from 1:2 to 1:3. A large example has the greater radius 55^{mm}; lesser, 16^{mm}.

The marginal plates are only moderately developed and do not encroach much on the disk, either above or below. In large examples there are about 37 to 39 on a side, in each series. They are convex and separated by wide and rather deep sutural grooves. The upper and lower nearly coincide. The upper ones are squarish, with rounded angles; the lower ones, along the disk margin, are higher than long. The odd interradial one is somewhat wedge-shaped, and only a little smaller than those adjacent to it.

The abactinal plates are round at top, convex, well separated; those of the radial areas and center of the disk are elevated, with a somewhat capitate top, covered by a dense cluster of slender,

elongated, acute, divergent spinules. Between most of the radial plates, over a large area, there are moderately large papular pores, about six around etch plate. Smaller pores are scattered over the center of the disk, but they are absent from small interradial areas and from the distal part of the rays.

The interactinal plates all bear dense groups of rather stout, elongated, tapered, mostly acute or subacute spinules, essentially like those of the lower marginal plates.

The marginal plates of both series are densely covered with small elongated, divergent spinules which overarch and partly conceal the sutural furrows. The spinules on the upper plates are slender and acute. Those on the lower plates, especially those on the actinal side, are longer and much stouter, terete and tapered, subacute or acute.

The jaws are rather large, rhombic; the two plates are separated by a rather wide sutural furrow covered with membrane; they are covered with spines on the margin and actinal side, like those of the adambulacral plates. The median, recurved epioral spine is large, somewhat compressed; the distal part is hyaline and very acute.

The adambulacral plates are transversely oblong, rather narrower than the adjacent interactinal plates. Each one, proximally, bears two, or more often three, unequal spinules of the furrow-series, but more distally they bear only two, nearly equal ones. On the actinal face each plate bears about four or five quite similar spines, which sometimes seem to stand, more or less distinctly, in pairs. These spines, like those of the furrow-series, are essentially like those of the interactinal plates, in size and form.

Regularly 4-rayed and 6-rayed specimens have been taken.

It is easily distinguished from our other species by the small marginal plates and stout interactinal spinules.

This species was taken by the U. S. Fish Commission at many localities, from off Martha's Vineyard to Florida, in 43 to 480 fathoms and more.

The Albatross also dredged another species in the West Indies, which is similar to *O. setosus* Ver., if not the same.

Suborder Notomyota (Ludwig).

Benthopectinidæ + *Pontasterinæ* Verrill, Revision Genera Starfishes, p. 217, 1899.

Pararchasterinæ Sladen, Asteroidea Challenger Exped., pp. xxviii and 4, 1889. Perrier, op. cit., 1894, p. 252.

Notomyota Ludwig (as an order), with families *Cheirasteridæ* and *Benthopectinidæ* Ludwig, Notomyota eine neue Ordnung der Seesterne. Sitzungsb. Köng. Preuss. Akad. Wissensch., vol. xxiii, pp. 435-466, 1910. Verrill, op. cit., pp. 283, 310,* 1914*a* (as a suborder.)

Benthopectinidæ Fisher, op. cit., 1911*b*, p. 120.

This group includes starfishes, mostly from the deep sea, having long, angular, subacute rays, in which there is a dorsal pair of special muscle bands running from the base to near the tip, and serving to curve the rays upward over the back. The podia are large and tapered, with a small terminal sucker, marginal plates of both rows are well developed with a tendency to become more or less alternate and often oblique. Their sutures are usually more or less fasciolate.

In the interradial angles some of the genera (e. g. *Benthopecten*) have an impaired median, marginal plate in both series; sometimes in only one series. Other genera have no odd plate. The marginal plates usually bear one or two long spines in both series and the surface is covered with acute spinules.

Dorsal surface is covered by protopaxillæ, parapaxillæ, spinose parapaxillæ, or simple spinose plates, rarely with true paxillæ.

Papulæ may be distributed over much of the dorsal surface of the rays, or may be limited to the proximal median part of the rays, or concentrated in specialized areas (*papularia*) near the base of the rays.

Actinal interradial area is small or may be nearly abortive; it is sometimes occupied by one to six or more large pectinate pedicellariæ.

Similar pectinate pedicellariæ may occur between the plates, on the marginals, or on the dorsal surface. Bivalve pedicellariæ occur in some genera.

Adambulacral plates have the inner end angular or prominent and projecting into the groove. It bears a row or comb of numerous slender spines; one, two or more larger spines stand on its actinal face, and sometimes a pedicellaria.

* Misspelled as *Myonota* on pages 283, 310, 311.

The most distinctive feature is the presence of a pair of definite dorsal muscle bands in the rays, extending from near the base to the tip and enabling the rays to be bent strongly upward with great facility. The order *Notomyota* was based on this character, as the name implies.

The large pectinate pedicellariæ, with numerous incurved papillæ, sometimes arising from and between two plates, are also characteristic of this group, but they are sometimes lacking, especially in the young.

Family Benthopectinidæ (Verrill) Fisher.

Benthopectinidæ and *Pontasterinæ* Verrill, Trans. Conn. Acad. Sci., x, pp. 200, 217, 1899.

Parachasteridæ Sladen, op. cit., 1889, p. 4.

Benthopectinidæ Fisher, 1911*b*, p. 120. Verrill, op. cit., p. 310, 1914*a*.

An almost strictly deep-sea family. Form stellate; disk rather small; rays five, elongated, with two rows of thick, spinose, marginal plates, which are not exactly paired, but are sometimes alternate, or nearly so. Adambulacral plates are angular and have elongated furrow-spines and one or more enlarged actinal spines.

The species of this family are numerous and occur in all oceans, but they are nearly all deep-sea species. Some of them extend to the greatest depths from which starfishes have been obtained. Only a few occur in depths less than 150 fathoms, none are found in very shallow water.

Those genera that have an impaired interradial marginal plate were formerly placed by me in a special family, *Benthopectinidæ*, later reduced to a subfamily, *Benthopectininæ*. The discovery of certain deep-sea species that vary in this respect, and others that are intermediate, renders it useless to longer maintain such a subfamily group. *Benthopecten spinosus* Ver. occurs in very deep water off the Atlantic coast of the United States. Other species occur in all the oceans.

It is represented in the West Indies by *B. simplex* (Perrier), which occurs in 1323 fathoms (Blake Exped.). Redescribed in detail (op. cit., 1894, pp. 254, 256) as *Pararchaster simplex*. It was described from a very young specimen.

Genus Cheiraster Studer.

Cheiraster Studer, Sitzungs. Naturf. Freunde, Berlin, xvi, pp. 130, 131, 1883; Anhang z. d. Abhandl. d. k. preuss. Akad. Wiss. Berlin, pp. 49, 51, 1884. (Type is *C. gazellæ* Studer.) Perrier, Exped. Trav. et Talisman, p. 269, 1894. Sladen, op. cit., 1889, pp. 3, 25. Ludwig, Notomyota, pp. 442, 454, 1910. Fisher, op. cit., 1911*b*, pp. 120, 123.

Pontaster (*pars*) Sladen, op. cit., pp. 23, 25, 1889. (Type of *Pontaster* is *P. tenuispinus*.)

Benthopectinidæ which normally have no odd interradial marginal plates. The papulæ, situated at the base of the rays, are not gathered into a special, median papularium, but form a bilobed group, often U-shaped or V-shaped, which, in the adult, may contain many papulæ and cover most of the base of the ray and extend on the disk but in the young it may contain only one to three or four pores and show no evidently bilobed character. The apex of the group is directed toward the disk.

The central part of the disk may, in the adult, bear a cluster of more or less numerous long acute spines, but these are few or lacking in the young, and in the adults of some species.

The dorsal surface is closely covered with low, round or angular irregularly arranged parapaxillæ or spinoparapaxillæ. A boss or short columnar process arises from the flatish plates, and is surmounted by a stellate marginal series of spinules or granules, and with one or several central spinules, which may be spiniform in some species, or granule-like in others. Distally the radial plates may become flatter, minute protopaxillæ.

The two rows of marginal plates are well-developed and usually decidedly alternate, and more or less angular, with oblique sutures. Each plate of both series usually bears one large acute marginal spine; often one, especially the lower one, may have one or several smaller secondary spines around its base. The surface of these plates is covered with small spinules or spiniform granules, larger beneath; the inferomarginals may also have one or two transverse rows of spines beneath, in some species.

The proximally angular adambulacral plates have a marginal series of numerous slender graded spines on the inner edges, which is continuous with a series of smaller spines around the outer margin. In the center of its actinal surface, each plate has one or two, or sometimes alternately one and two, larger, acute, usually erect spines.

Pectinate pedicellariæ may be present on the interactinal plates, or between them, or on the inner end of the inferomarginal plates, or sometimes on the adambulacrals. They may be few or many, or entirely lacking, especially in the young.

Ludwig (op. cit., 1910) made the external generic distinction between this genus and *Luidiaster* almost entirely dependent on the presence of one spine, in this, on the actinal side of the adambulacral plate, while in *Luidiaster* there are two or more. This, however, is not a valid generic difference, for several of the species have either one or two, on consecutive plates, and nearly all have two, in large specimens, on some of the plates.

The internal dorsal muscular bands of the rays are not attached to a crest of the proximal ambulacral ossicles, in those species examined. According to Fisher, this is the most definite character for separating it from *Luidiaster*. The same character seems to separate it from *Pectinaster*. But the muscular bands are not known in many species. Dry specimens and unique types cannot be examined as to this feature.

Young specimens less than 20^{mm} in diameter usually cannot be referred with any certainty to either genus, for their popularia, pedicellariæ, and characteristic marginal spines may be lacking or rudimentary.

Cheiraster mirabilis Perrier.

Archaster mirabilis (*pars*) Perrier, Bull. Mus. Comp. Zoöl., vol. ix, p. 27, 1881; Nouv. Arch. du Mus., vol. vi, p. 256, pl. 9, fig. 4; not pl. viii, figs. 7, 8, (nor pl. x, fig. 3), 1884.

Cheiraster coronatus (*pars*) Perrier, Exp. Sci. Travail. et Talisman, Echinod., p. 271, 1894.

Archaster coronatus (*pars*) Perrier, op. cit., 262, 1884; op. cit., p. 271, 1894 (full descr. two varieties.)

Cheiraster coronatus (*pars*) Ludwig, Notomyota, op. cit., pp. 455, 456, 1910.

Plate xiv; figures 5, 5*a*. Details.

The type of this species, as described by Perrier in 1881 and copied in 1884, is the very same specimen (from station 148, St. Kitts) as that described by him in 1894 (p. 271), as "*Cheiraster coronatus*" "A. Premier type, bras ellongés," and there made the typical form of the latter. This is, of course, contrary to the ordinary rules of nomenclature, for *mirabilis* has three years

priority, and was described from a single type-specimen.[20] *C. coronatus* was not described till 1884, and its type was from off Havana, in 805 fathoms, No. 2.

Therefore his *C. coronatus* of 1894 is the same thing as his *A. mirabilis* of 1881. Whether his *C. coronatus* of 1884 is a distinct species, is another question, to be settled only by a new study of the type, or other specimens identical in character.

The type of this species, according to the revised description by Perrier (1894, p. 271) under the later name of *C. coronatus*, has the following characters:

Radii 10^{mm} and 85^{mm}; ratio, 1:8.5. The rays are long and slender. Marginal plates forty to forty-two. The center of the disk has about a dozen large spines.

The superomarginal plates are rather small, imbricated, their proximal convex border alone being visible. They agree in number with the inferomarginals, but are not in line with them. Their surface is covered with numerous fine spinules. Those beyond the third bear a large conical marginal spine; that on the fourth plate is usually much larger than the others. Those of the first to third plates are more or less aborted.

The inferomarginal plates are covered with long and slender spinules; on the first three plates there are also four or five spines, increasing in size upward; on the fourth plate the large marginal spine becomes 7 to 8^{mm} in length; those beyond gradually decrease in length; below the large spine there is usually at least one secondary spine. Some of these plates have a rudimentary fasciculate pedicellaria.

The dorsal plates are numerous, small, rounded, flat, covered with extremely small spinules, almost reduced to the form of granules visible only with a lens.

The center of the disk has about a dozen long, conical, movable spines. (Condensed from Perrier.)

The papular pores form two symmetrical lateral groups, which are prolonged toward the center of the disk and become coalescent at a larger radial plate. Five larger interradial plates are

[20] At the end of the 1881 description there is a brief description of another specimen, which in 1884 he made the type of a new species (*A. insignis*), which is now *Dytaster insignis*. Thus the name *mirabilis* cannot be applied to any species except that first described, with the type specimen, from Station 148, in 380 meters, off St. Kitts, as its sole type.

also distinguishable. Some of the plates on the papular areas are enlarged and similar to those that have a central spine. The madreporic plate is large, round, and covered with radial gyri. It is surrounded by plates bearing larger spinules; that on the adcentral side is largest.

The adambulacral plates project into the groove; the inner edge bears ten to twelve graded spines, the middle one longest; the rest of the margin, on the actinal side, bears about a dozen very small conical spinelets. On the center of the actinal face there is one large, movable, conical spine. On some of the plates there are one to three small spinelets around its base. (In some of our specimens part of these plates have two unequal, long, slender spines.)

The interactinal plates form three series; the first has six plates (three each side); the second has four; the third two. These plates bear a set of spines about parallel with the adambulacrals; one of the inner plates of the first row is longer and larger; other small spinules cover the plates.

Two or three pectinate pedicellariæ occur on the sutures of these plates, one on each series. They have five or six papillæ on each half.

The jaws are prominent, each half is wedge-shaped, and bears about eleven marginal spines, the two inner much the larger; the lateral ones slender, subequal. Epioral spines are numerous; three inner ones are larger.

Some of the specimens before me agree well with the characters given by Perrier for his original type, and agree with some of his cotypes that I have studied in the Museum of Comparative Zoölogy. Many of these are evidently immature.

Perrier (1894, p. 271) made the presence of a group of spines on the center of the disk the special character of this species (under the name *coronatus*) and stated that this separates it from all the other species of the West Indian fauna.

In this statement he certainly went too far, for at least two other species have the same feature. Very likely, therefore, he still included in his species specimens of more than one species.

He recognized two varieties: one with short and the other with long rays, the latter being the typical *mirabilis*, as shown above. The form with short rays may be distinct. Its type was from

station 238, in 127 fathoms, off Camman. It may be identical with *C echinulatus* Per., as now understood by me. It is perhaps the form figured by Perrier (1884) on pl. x, fig. 2.

Ludwig (op. cit., p. 455, 1910) considered *C. mirabilis* the young of *coronatus* and erroneously adopted the latter name. The name *mirabilis* has three years of priority. Moreover the type specimen of *mirabilis* was larger than that of *coronatus.* Perrier, 1894, kept the two as distinct species, though he displaced the names and put his former types of *coronatus* with that of *mirabilis.*

With only the records given by Perrier, it is not possible to give accurately the distribution of this species in the Blake dredgings, separately from the other forms compared with it by him, in 1884, for in most cases he gives no information even as to the presence of spines on the disk. The following stations, however, are valid for this form:

Station 148, off St. Kitts, in 208 fathoms, fine sand; station 238, off Grenadines, in 126 fathoms, coral sand; station 264, off Grenada, in 416 fathoms, gray ooze; station 291 in 200 fathoms, off Barbados. Most of the above have been confirmed by examinations of the specimens.

It was also taken by the Albatross at a number of stations, in similar depths. The Bahama Expedition dredged specimens at station 2, off Havana, in 210 fathoms.

Cheiraster mirabilis coronatus (Perrier).

Archaster coronatus Perrier, op. cit., 1884, p. 262.
Cheiraster coronatus Perrier (*pars*), 1894, pp. 271, 275 (not the form then described).
C. coronatus (*pars*) Ludwig, op. cit., pp. 455, 456, 1910.

The type of this species, as originally described by Perrier, in 1884 (p. 262) was from Blake station 2, in 805 fathoms. Its characters, which were given briefly, are as follows:

Radii 8^{mm} and 65^{mm}; ratio, 1:8.1. Superomarginal plates 43. The rays are slender and long, with the interradial angles scarcely rounded.

The superomarginal plates are longer than broad, angles rounded; each bears one median marginal spine; that of the

fourth plate is larger than the others; those of the two more proximal plates [21] are much smaller; none on the first.

Inferomarginal plates have a marginal spine much larger than the others, surrounded at base by several smaller spines less than half as long; otherwise the plate is covered with small spinelets.

The dorsal paxillæ are rather small, covered with equal small spinules. About fifteen long, slender, acute spines surround the center of the disk. Madreporic plate is small, prominent, rounded, pretty coarsely grooved, situated near the marginal plates.

The interactinal plates are in a single series with small spines. (No pedicellariæ are mentioned.) The adambulacral plates bear a semicircular row of nine graded marginal spines, and a single straight, long, slender, acute spine on the actinal face.

The jaw-plates bear, each, ten marginal spines, decreasing from the oral end backward, and also some small epioral spines, both on the surface and bordering the naked sutural area between them.

The papular pores are not mentioned by Perrier, nor any pedicellariæ.

So far as his description shows, there is no character by which this form is distinguishable from typical *C. mirabilis*, but a re-examination of the type is desirable, especially with reference to the papular arrangement and the special characters of the dorsal parapaxillæ.

Among my notes, made when I examined the Blake collection, in 1899, there is no mention of the type of this species. Probably I did not see it. Most likely this is only a slight variation from the typical form of the original *C. mirabilis*, as suggested by Perrier himself, in 1894. The only point worthy of note, in the description of Perrier, is the apparently more spinose condition of the inferomarginal plates, in this respect approaching those of *C. echinulatus*. Perrier gave only two localities: station 2, off Havana, in 805 fathoms, and station 19, off West Florida, in 310 fathoms (one very young).

21 Perrier says *third* and *fourth* plates, evidently by an error, for second and third. In this respect his description, when corrected, applies well to his figure, pl. ix, fig. 4 = *C. mirabilis*.

CHEIRASTER ECHINULATUS Perrier.

Archaster echinulatus Perrier, Revision, vol. v, p. 268, 1876; Etoiles de Mer, p. 263, pl. x, fig. 4, 1884.

Cheiraster echinulatus Perrier, Exped. Trav. et Talisman, p. 278, 1894 (brief description.)

Pectinaster echinulatus Ludwig, Notomyota, pp. 449, 450, 1910 (no description.)

Plate xiv; figures 2, 3. Details. Plate xix; figure 2. Plate xxv; figure 1.

The single specimen originally described by Perrier, from off Barbados, was very young, and most of those later listed from the Blake Expedition are also small. Neither of his descriptions are very complete, nor does his small photographic figure give much aid in identification. I have examined part of the specimens recorded by him, however, and therefore refer much larger specimens to his species.

According to Perrier (1876) his type had the radii 4^{mm} and 16^{mm}; ratio, 1:4; marginal plates, 15. The largest specimen mentioned later had 19 marginal plates. Some of our specimens have 26 or more.

In the type the adambulacral plates had a circular marginal group of ten to twelve slender spines, the largest on the inner angle, and one larger spine on the center of the actinal face.

The inferomarginal plates have one marginal spine, not particularly long, and several unequal secondary spines, below its base, some of which are not very much shorter than the large one. The superomarginal plate has one larger spine, as in most species.

The papular pores were "one to three at the base of the rays, near the median line."

The dorsal paxillæ were rather large, with about ten marginal granules.

The jaw-plates have each a row of about nine long, slender, close spines, with the two rows opposed to each other, and a larger tooth-like spine.[22]

[22] The type, according to Perrier (1876), came from off Barbados, in 100 to 315 feet, Hassler Expedition. Probably *fathoms* were here intended for most of the Hassler dredgings there were in 75 to 100 fathoms, and this is a rather deep-water species.

These details are now given because this was the first species of the family to be described from the West Indian fauna, and because, owing to its marked immaturity, its identification, from the imperfect description, is difficult. Moreover, there has been a question as to its generic place, since Ludwig has referred it to *Pectinaster* and has made it the young of my *Pontaster sepitus* (1885) 1895.* Both these conclusions are erroneous.

In 1884, Perrier only added that only two interactinal plates separated the inferomarginals from the jaws (a feature of the young); that these plates have pectinate pedicellariæ; that the dorsal paxillæ have a central caducous spinule; that the ambulacral feet have small suckers; that the number of marginal plates varies from fifteen to nineteen; that the dorsal marginal spines have a number of spinules around their base; and that in the larger specimens some pretty long spines surround the center of the disk.

Most of these features are common to several other species, especially when young. The last two are of most importance, though other related species have spines on the disk.

The most distinctive character given is the presence of numerous secondary spines around both series of larger marginals.

In 1894 he referred the species to *Cheiraster*, although he recognized *Pontaster* and *Pectinaster*[23] as distinct genera; and stated that it is nearly related to *C. mirabilis* but may be distinguished by its shorter rays, broader at base; its circular pectinate pedicellariæ; its larger inferomarginal spines, accompanied by several spines of smaller size; and by the larger size of the dorsal paxillæ. He adds that the interactinal plates are two to six in a single range (a youthful character).

In neither place does he describe the correct arrangement of the papulæ, which would be the only character by which it could be distinguished from *Pectinaster*. This we can now supply by

* *Archaster sepitus* Verrill, Amer. Jour. Sci., vol. xxix, p. 151, Feb., 1885; Expl. by the Albatross in 1883, pp. 519, 543, 1885. *Pontaster sepitus* Verrill, Proc. Nat. Mus., vol. xvii, p. 247, 1894; ditto, vol. xlix, p. 137, 1895. Range, 368 to 858 fathoms. Taken at several stations between N. lat. 41° 53′ and 39° 40′.

23 Ludwig (1910) referred this species to *Pectinaster*. Perhaps he was misled by Perrier's imperfect description of the papular areas. Perrier apparently saw but one limb of the V-shaped group.

means of larger specimens. In his immature specimens the papular areas were feebly developed, and probably hard to see.

The Bahama Expedition dredged four good specimens at station 61. One of these, in alcohol, has the radii 9^{mm} and 36^{mm}; ratio, 1:4. Marginal plates 26.

It has about twenty larger, tapered, acute spines on the central part of the disk, with a number of others bordering and on the papular areas, not so large, and grading down to the spinose parapaxillæ of the radial area, which are scattered among the ordinary form, even to the distal fifth of the ray, those beyond the basal part of the ray having the central spinelet small, but acute, surrounded on the larger ones with an inner circle of about eight to ten very small clavate spinules, and an outer circle of twelve to sixteen or more. Those plates that lack the acute spinelet have a central clavate spinule like those around it, or often two or three of them. Toward the tips of the rays the plates become very small, closely crowded, so that when denuded they are polygonal and in mosaic. They bear few granule-like spinules in small rosettes.

The papular pores are in a bilobed or V-shaped group, the apex adcentral, each limb having two rows of six to eight each. The two limbs are separated at first only by the single median row of plates, more distally by two or three rows. The two main rows of each limb are separated by a single line of plates, and they converge adcentrally, and finally are united by a line of two or three pores just adcentral to the largest spine on the group, arising from a prominent plate, in the apex of the V. The papular pores are very small and difficult to see, even with a good lens, on some of the specimens. There is sometimes a third short outer row of papulæ on each limb in the larger specimens.

The superomarginal plates are rather large, convex, and encroach upon the disk forming a strong narrow border, widest in the interradial areas, where the sutures are transverse. Beyond the third plate the sutures become more and more oblique and the plates more rhomboidal. Each of these plates, except the first, bears an acute tapered, slender spine, not very long, hardly equal to the length of two adjacent plates. That on the fourth plate is not notably enlarged, those on the second and third be-

ing only a little smaller. The first plate usually has the spine rudimentary or lacking. Below the base of these spines there are proximally usually two or three small, acute, secondary spines. The surface of the plate is covered rather thickly with short, acute, erect spinules; those below the spine are longer. The sutures between the plates are wide, but only feebly fasciolated.

The inferomarginal plates are thick and form a strong raised border to the under side of the disk and rays, which appear sunken below the border. These are more strongly spinulose than the upper ones, especially on the outer part, where the spinules become large and sharp. Each of the plates bears one large marginal spine, similar to the dorsals, but rather longer. Below this, on the proximal plates there is a double group of five or six secondary spines, one or two of them about half as long as the large one. More distally these become reduced to two or three. These and the coarse spinules between them give the under surface a very spinose appearance.

The adambulacral plates have a very prominent inner angle which bears a row of eight to ten slender graded spines, continued around the actinal edges by more slender spinules. On the actinal face are borne proximally either a single large tapered spine, or else two unequal spines; in the latter case the smaller spine may be on the aboral or on the adoral side of the larger one. The plates with two spines may alternate irregularly with those with only one. Beyond the middle of the ray most of the plates bear two nearly equal spines.

The interactinal plates form, on each area, one row of about eight plates, and a shorter row of four or five small plates.

Pectinate pedicellariæ, broad ovate in form, with raised borders, are present over the sutures between part of the larger interactinals. There may be from one to four on each area; most often two; sometimes none. These plates also bear a central spine, with basal spinules around it. Peroral spines are rather large and stout.

These specimens are considerably larger than those seen by Perrier, but they differ little except in those features naturally due to increased age. In my specimens the character of the papular areas is that of typical *Cheiraster*, and not at all like *Pectinaster*, in which Ludwig placed the species.

The localities where it was taken by the Blake, as recorded by Perrier, were mostly in the Gulf of Mexico, off West Florida and Alabama, in 84 to 229 fathoms. I have also seen it from station 158 (?), off Montserrat, in 147 or 148 fathoms.

It was taken by the Albatross at several stations in the West Indies, among others at station 2125, in 208 fathoms, off Curacoa, No. 10,109, Nat. Mus. (See plate xiv, fig. 3.)

By the Bahama Expedition it was taken at stations 31, 35, 61, off Key West, Fla., in 75 to 100 fathoms (see plate xix, fig. 2); and at station 2, off Havana, in 110 fathoms. (See plate xiv, fig. 2.)

CHEIRASTER PLANUS Verrill, sp. nov.

Plate xviii; figure 2. Type.

Of this species I have seen but one specimen (No. 18469, Nat. Mus.).

The disk is rather wide for the genus and the rays long, becoming very slender distally. Radii are 13^{mm} and 92^{mm}; ratio, 1:7. Marginal plates, 39. Radius of disk is equal to five and one-half proximal plates. Paxillar area is equal to three times the breadth of second marginal plate.

The superomarginal plates of the rays are rather large, somewhat convex, forming a thick but not wide somewhat raised border. They are rather rhomboidal with oblique sutures and alternate with the lower ones.

Each bears a rather long, slender, terete, regularly tapered, acute spine, in length about equal to two plates; that on the fourth plate not much larger than the following; those on the second and third are somewhat smaller; the first very small. Rest of the plate nearly uniformly covered with very small, slender, acute, spaced spinelets; the sutures are fasciolated with more slender spinules.

Inferomarginal plates have a similar marginal spine, but with one or two secondary spines, not half as long, below it on the proximal plates; elsewhere the surface is covered with acute spaced spinelets, larger than those on upper plates, grading downward to short appressed conical forms. About sixteen proximal adambulacral plates correspond to the first ten inferomarginals.

very small, roundish plates that are not much crowded. They bear a very small stellate group of minute spinules, which, on the larger radial plates, form a marginal row of about six to nine, around a central one of the same size or slightly larger and acute. Those on the papular areas, around the madreporic plate and on the central part of the disk are partly larger with larger and more numerous spinules. On the papular areas, interradial areas, and near bases of the rays some of them bear a small central spine; some of these exceeding the diameter of the plate. These are not found much beyond the bases of the rays, except a few sparsely scattered along the ray, of smaller sizes.

The papular areas are large and well defined, U-shaped, with two rows of about six or seven pores in each limb. They are slightly raised above the general level.

The madreporic plate is irregular in form, not very large, deeply grooved, and surrounded by six enlarged parapaxillæ.

The combined jaw-plates are broad-ovate with the oral edge broadly rounded and bearing four rather large and stout, blunt peroral spines; on one jaw there is a median odd one, deeper in the mouth. The lateral marginal row has six slender spines. Epioral spines are not very numerous, in two or three rows on each side, the anterior pair larger.

The adambulacral plates have a prominent obtusely angular and rounded inner margin, which bears a row of eight to ten slender graded spines, continued along the actinal edges by smaller spinelets. The actinal face has one rather large and stout, tapered, central spine; some few plates have a smaller secondary spine.

The interactinal plates form two rows; counting both ends the first row has eight or ten plates; the second has about four, with others rudimentary. They are spinulated like the inferomarginals and some of the larger ones have a central erect spine.

No pedicellariæ of any kind could be found.

This is a very distinct species, unless some of the young, without discal spines, called *mirabilis* by Perrier, prove to be its young. Most of them, however, have a very different papular area, when any is visible. The absence of pedicellariæ may be merely an individual peculiarity, but is unusual in this genus, with specimens so large.

All the marginal plates have clearly fasciolated sutural grooves.

This specimen was taken by the Albatross in the winter of 1885, in the West Indies, but the locality was not recorded. (No. 28469, Nat. Mus.)

CHEIRASTER ENOPLUS Verrill, sp. nov.

Plate xviii; figure 1. Type.

A large species with a wide, flat disk and long, tapering, angular rays, armed with two rows of long, tapered, acute spines, one to a plate, and with a central group of 12 to 15 long, slender, acute spines on the disk. Superomarginal spines are nearly confined to lateral surfaces, so that the paxillar area is wide and covered with very small, even parapaxillæ.

Radii of the type are 21 and 185^{mm}; ratio, 1:9. Marginal plates about sixty. The sides of the disk are evenly and broadly incurved, and in the median interradial areas the superomarginal plates scarcely reach the upper edge and do not form a rim, but farther out they form a narrow, slightly raised rim. The primary plates and those more central bear each a long, slender, terete, very acute spine, about fifteen altogether. The central plate and spine are the largest.

The general surface of the disk and rays is covered very closely with very small rounded, convex, low parapaxillæ, covered with minute spiniform granules or with short, minute spinules. Those on the disk and bases of rays are larger, and have about 10 to 15 spinules around the edge, and a central rosette of three to twelve granules; about midlength of the rays they may have only six to eight marginal spinules and one or two central granules. Toward the tips of the rays they become almost microscopic.

Many of the larger parapaxillæ on the papular areas, and on the interradial areas have a small, erect, acute central spine.

The madreporic plate is large and convex with radiating gyri. It is surrounded by six convex paxilliform plates, larger and higher than the rest, each bearing a small spine.

The papular areas are large and broad, occupying more than half the width of the base of the ray, and extending, on the disk, to the cluster of long spines. There may be more than 200 small papulæ in each half.

The half areas are long elliptical, pointed distally and divergent, united at two places by narrow cross-rows of papulæ.

The superomarginal plates are small, narrow, convex above, angular below, alternating irregularly with the lower series. The surface is evenly covered with very small, acute spinuliform granules, similar to those of the adjacent parapaxillæ. Each bears one large, outspreading, terete, evenly tapered, very acute spine, some of them 15^{mm} long, or as long as the width of the ray at base. They have no secondary basal spines. Those on the first three interradial plates are much smaller than most; the first one is smallest. The fourth and fifth are largest; beyond that they decrease regularly.

The same arrangement, as to size, holds good for the inferomarginal spines, which are of similar length, but rather more slender. But these last have a group of three to five unequal smaller sized spines below them, one of which may be half as long as the primary spine. A row of similar acute spines extends along both the transverse under margins of the plate, two or three in each row, proximally. The rest of the surface is covered with small, erect, acute spinules. Close to its inner end there is often one (sometimes two) small, low, papilliform pedicellariæ, with six to eight small convergent valves.

The interactinal plates are in three chevron-like rows. The first forms a rather long row, next the adambulacrals; each half has six or seven plates. Each plate bears one or two slender spines, and usually a papillose, elliptical pedicellaria, with twelve to sixteen incurved papillæ. These often cover more than half the plate. Others of similar size and form occur in the sutures between two plates.

The adambulacral plates have a prominent, widely curved or often nearly semicircular inner edge on which there is a regular row of about 10 to 12 slender graded spines; this row is continued on the adoral and aboral edges by about six to eight much smaller spines or spinules. The actinal surface is concave and bears usually two long, rather slender spines, which on the proximal plates become more and more unequal, the outer spine becoming shorter and smaller, until on the basal three or four plates it is reduced to a rudimentary condition and may entirely

disappear on some plates. A few miliary spinelets may occur around the bases of the large ones.

The combined jaw-plates are broad and short, with a wide elliptical suture, and a very broadly curved peroral edge, which bears two pairs of stout, blunt, peroral spines, the two middle ones considerably larger. The adoral row on each side has eight to ten slender spines, like other adambulacrals in size, but in a slightly curved row, the most adoral spine longest. Epioral spines are not very numerous, slender, acute.

The type, and only specimen seen, is from Albatross station 2128, N. lat. 19° 55′ 46″; W. long. 75° 49′ 23″, south of East Cuba, in 400 fathoms, blue mud and fine sand. (No. 7425, Nat. Mus.) It is dry, color yellowish brown.

In general appearance this is like *Luidiaster*, but it has the pedicellariæ and papulæ more like those of *Cheiraster*. I attach no generic importance to the presence of two large adambulacral spines on most of the plates.

The dry specimen affords no chance to ascertain the attachment of the radial muscular bands, which seems to be the only real distinction between the two genera.

Genus Pectinaster Perrier (emended).

Archaster (*pars*) Perrier, Etoiles de Mer, p. 263, 1884.

Pectinaster (*pars*) Perrier, Ann. Sci. Nat., vol. xix, p. 70, 1885 (type *P. filholi* Per.); Exped. Trav. et Talisman, p. 278, 1894. Ludwig (emended), Notomyota, op. cit., p. 448, 1910. Fisher, op. cit., 1911*b*, p. 122.

Pontaster (*pars*) Sladen, op. cit., p. 23, 1889.

Cheiraster (*pars*) Ludwig, Asteroidea, p. 1, 1905.

Form regularly stellate, with regularly tapered angular rays, normally five. Odd interradial marginal plates lacking. Dorsal radial paxillary areas rather narrow, reaching the tip of the rays, covered with small, roundish, low or convex plates, bearing small spinules and often a larger central spine, on some of them.

Papularia specialized at base of rays, medial or central, and more or less smaller, but not two-lobed.

Marginal plates are well developed, usually not particularly large, more or less out of line in the two rows, so that the vertical sutures do not correspond, and are somewhat oblique. Those of both series are spinulose and bear one large spine, often with one

or more smaller ones at its base. The sutures are more or less fasciolated.

Interactinal plates are present, in small numbers. They are spinulose and may have a central larger spine, and often sutural pectinate pedicellariæ.

The adambulacral plates have a prominent inner angle, which bears, at its edge, a row of six to ten or more spines; the actinal side has one or two large central spines and often a smaller accessory one, besides some small basal spinules. Sometimes there are two or more equal spines.

The pericellariæ are fasciculate or pectinate. They may occur on any series of plates; rarely on the adambulacrals. Those on the interactinals are pectinate and usually largest. They may cover the suture between two plates, or occupy a single plate. Those on the dorsal plates are small, fasciculate, and are not always present.

The dorsal muscle-bands are well developed. Their proximal ends are attached to one or two ambulacral plates and to the superomarginals.

This genus is closely allied to *Pontaster.* The latter (typical) differs chiefly in having two-valved pedicellariæ, instead of pectinate ones; and in their position, for they mostly occur on the adambulacral plates. These plates also have two or more larger spines on the actinal side, instead of one or two, as is usually the case in this genus.

The number of actinal adambulacral spines cannot be trusted as a true generic character, for it varies on different plates of the same ray, but in this genus they seldom form a cluster, as they sometimes do in *Pontaster.*

Typical *Pontaster* also has more crowded papulæ and more specialized papularia, with a more complex calcified inner structure, and they are therefore more swollen externally than in this genus, in which they are sometimes scarcely at all swollen, especially in the young.

Fisher (1911*b*) made the bivalve form of the pedicellariæ and their position on the adambulacral plates the most diagnostic character to separate *Pontaster* from *Pectinaster.* This seems to me the most useful and most available method, except in those rather unusual cases when no pedicellariæ occur, and in the very young.

Young specimens, up to 25^{mm} in diameter, are often generically undeterminable, if pedicellariæ are not present. At this stage of growth there is usually only one papular pore developed, but that is median at the base of the ray. A little later two more appear, one each side of the first. These and later conditions may coëxist on the different rays of the same specimen, owing to unequal rates of development.

This genus is common in moderately deep water of all the oceans. Some of the species descend to great depths.

PECTINASTER VINCENTI (Per.) Ludwig.

Cheiraster vincenti Perrier, Exped. Trav. et Talisman, pp. 270, 275, 1894 (short description.)

Archaster mirabilis (*pars*) Perrier, Etoiles de Mer, p. 256, 1884 (= No. 231, p. 258.)

Luidiaster vincenti Ludwig, Notomyota, op. cit. 1910, pp. 452, 453, 1910.

According to the brief description given by Perrier in 1884 (p. 258) this species has the following characters, based on the types from station 231:

The rays are rather short; radii are 10^{mm} and 50^{mm}; ratio, 1:5. Superomarginal spines are 28. There are no large spines on the central part of the disk. The adambulacral spines have, on the actinal side, a group of three or four spines, instead of one or two as usual.

The superomarginal and inferomarginal spines are shorter than in *C. mirabilis*.

The dorsal parapaxillæ have mostly a larger spinule in the center.

The pectinate pedicellariæ, on the interactinal plates, are well developed, but variable in number and position, even on the different areas of the same specimen. There may be from one to four, or none at all on any one area.

In 1894 (p. 275) a few additions are made to the description: The large inferomarginal spine is accompanied by two or three smaller spines irregularly placed, and not constant.

The papulæ are arranged in a small median group, not very prominent (as it is in *Pontaster*, sp.). He compares it to *Pectinaster oxyacanthus* (Sladen, as *Pontaster*) but finds it quite distinct. As Perrier states dictinctly that the papularium is central "sur une plage impaire," this species should be placed in *Pectinaster*, not in *Luidiaster*, where Ludwig located it, or else

in *Pontaster*, if the character of the pedicellariæ be ignored, for in the type of the latter the pedicellariæ are bivalved. Moreover, in typical *Pontaster* the papularia are more swollen and have a specialized calcareous framework internally.

The type was from station 231, off St. Vincent, in 95 fathoms (six specimens). The specimens from this locality, in the Blake collection, I have seen. They are all young except one.

Pectinaster mixtus Verrill, sp. nov.

Cheiraster mirabilis (*pars*) Perrier, op. cit., 1884 (*non* 1881), p. 256, pl. viii, figs. 7, 8; op. cit., p. 276*c*, pl. xx, fig. 4, 1894.

Plate vi; figure 2. Plate xv; figure 2. Plate xvii; figure 1.

It seems necessary, or at least desirable, to have a special name for the very common and often abundant small form of this group found in the West Indies. It is probably more abundant and more widely diffused than any other starfish of that region, in moderate depths. It also has a considerable range in depth.

At present it is impossible to tell whether any of the specimens are mature. Most are evidently immature, but cannot be referred to either of the larger species with certainty. Certainly they are not all of one species, as first described. Large numbers of specimens have been grouped together by Perrier (as his *C. mirabilis* of 1894, not of 1881). I have examined a considerable number of his lots, but not all, and have found some evidently mixed lots, including, for instance, the young of *C. echinulatus.* Others might be the young of *C. planus* or *P. vincenti.* Still, most of them appear to belong together. I propose to call the more common species, provisionally at least, *C. mixtus* = *C. mirabilis* Per., 1894, in part. Although the specimens are probably all immature I am unable to refer them to either of the larger species described.

A specimen that agrees very closely with the one described by Perrier comes from Albatross station 2341, off West Florida, in 143 fathoms (No. 10,226, Nat. Mus.). This may be taken as the type. (See plate vi, figure 2.)

It has the radii 6^{mm} and 26^{mm}; marginal plates 22. The dorsal plates are nearly flat, polygonal, closely packed or tesselated, unequal in size. They bear numerous minute, almost granule-like

spinelets in a rosette of two circles on the larger plates, about ten to twelve in the inner circle and twenty to twenty-four or more in the outer one, and many of the larger plates have an erect central sharp spinelet, often more than twice as long as the diameter of the plate. There is no central group of larger spines on the disk, but some of the plates there are a little larger than the average.

The papular pores are in a small, median, specialized cluster of five or six. A central larger pore is surrounded by four plates, a little larger and more prominent than those adjacent, and with a rather larger central spinelet. The side of each plate next the pore is angulated and bears a miniature comb of minute spinules. Thus the four plates are convergent over the pore, and appear to be movable, to some extent, like an operculum, for in some cases they lie flat and conceal the pore and in other cases they have the inner end raised, exposing it. Two of these plates are in the median radial line; the others are between them, to right and left.[24] Two or four smaller pores appear between the outer angles of these four plates. No others are visible on some of the rays; on others an additional small pair appears more distally. The central dorsal pore is distinct.

The superomarginal plates have a small acute spine; that on the fourth plate is only slightly longer; some of the more proximal plates have two spines, one above the other.

The inferomarginal plates have one marginal spine, equal to the upper ones, and also have a group of four to six or more secondary sharp spines, of unequal sizes, below their base, some of them half as long as the marginals. These grade downward into numerous sharp spinelets that closely cover the inferior surface, the lower ones minute.

The adambulacral plates have a prominent angulated inner end and bear a series of about seven to nine very slender spines on the edge. The actinal face usually has two elongated, very slender, sharp, unequal, larger spines. Sometimes a fasciculated, papilliform pedicellaria, with about four valves, replaces the two spines on some of these plates.

[24] These appear to be the same as those spoken of by Perrier as four plates forming a cross.

The interactinal plates form one row of four or six, and four rudimentary plates of a second row.

Pectinate pedicellariæ, nearly circular in form, exist between most of the plates of the first row and rudimentary ones between those of the second row, so that there are three, four, or more on each area.

The four apical or peroral spines are much stouter than the adorals and blunt, the two central ones most so, but not long. Each row of adoral or lateral spines has about nine slender, closely packed, subequal, and not very long spines. There are ten to twelve crowded, small epioral spines on each jaw-plate, the adoral one larger.

Younger specimens, with the greater radius 12 to 13^{mm}, have the same form and many of the special characters are developed. They have 12 marginal plates, obliquely placed. There is but one papular pore on each radial area. That is median and represents the larger median pore of the type. It is surrounded by four polygonal plates. When the dorsal plates are denuded of spines they appear closely united in a mosaic; they are of unequal sizes, larger than in most species, only slightly convex, and distinctly polygonal. On the disk and bases of the rays they are larger and many are regularly hexagonal. They retain the polygonal form nearly to the tips of the rays.

Adambulacral plates have six to eight very slender furrow-spines and part have two slender spines on the actinal side. There are only four interactinal plates, and only one rudimentary pectinate pedicellaria, in some; while in other young of similar size there are two pedicellariæ to each area.

According to Perrier's description in 1894 (p. 276) of what he then called *C. mirabilis* the specimens (mostly very young) had the following characters:

The larger radius does not exceed 30^{mm}. The superomarginal plates are twenty-two; they stand obliquely and alternate with the lower ones and extend somewhat onto the upper surface; their outline, seen from above, is a parallelogram with inclined sides; they are covered with small spinules and have one pretty long marginal spine on each plate.

The inferomarginals are a little longer than wide; they are covered with small spines and have one long acute marginal

spine, as long as a plate, often with a smaller spine at its base. Sometimes there is a small pectinate pedicellaria between two of these plates.

The dorsal parapaxillæ have roundish, flat bases, and bear about thirty almost granule-like, obtuse spinules and on most of them a delicate central spinelet.

The papulæ, at the base of each ray, vary from one to eight, according to age. One of these is larger than the rest and is situated in the median radial line. It is surrounded by four plates, which form a cross, and they are larger than those adjacent. The other papulæ are situated in the same transverse line, or else a little more distal.

The interactinal plates are six to eight and form only one row. In the suture between some of them there is a pectinate pedicellaria, with six to eight papillæ; other pedicellariæ, smaller in size, may be present.

The adambulacral plates project strongly into the groove and each bears an inner marginal row of eight graded spines; other smaller spines continue the rows on the actinal edges. A large spine stands on the actinal side, sometimes accompanied by a smaller spine.

Several of the characters given above are due to immaturity, especially the small number of papular pores, of marginal plates, and of interactinal plates. M. Perrier here restricts the name *mirabilis* to those specimens that lack long spines on the central part of the disk. This feature is, without doubt, in some cases due to immaturity and yet there are allied species that do not have them, even when of large size. Therefore there may be more than one species among the numerous small specimens listed by Perrier as *C. mirabilis,* without central spines. A young specimen of the same species (No. 18,470 Nat. Mus.) differs only in characters due to its less development. Radii are 4^{mm} and 18^{mm}. Its dorsal plates are flat, polygonal, and tesselated quite regularly. This feature alone is sufficient to distinguish it from the young of other species of similar size. Most of the larger dorsal plates have an acute, erect, central spinelet. Its papular pores are single on some of the rays. In that case there is only the primary pore surrounded by its four special plates. On some of the rays a small pore has already appeared on one

or both sides of the first, between the outer angles of the four plates, but not always in the same angles. The inferomarginal spines are surrounded by basal secondary spines as in the larger specimens. (See plate xvii, figure 1.)

The spines of the jaws and adambulacral plates are essentially the same as in the older specimen described above; part of the adambulacral plates even have two larger spines on the actinal face.

Interactinal row of plates is single, having two larger and two very small plates. Two or three small pectinate pedicellariæ have already developed on each area.

This is undoubtedly young. In the strong spinulation of the inferomarginal plates and the group of several secondary spines below the marginal one it is much like *C. echinulatus*, but the latter has a group of long spines on the disk; a different arrangement of papulæ; relatively coarser protopaxillæ, with fewer and smaller central spinelets. It seems hardly probable that it can be the young of *echinulatus*, for there is no great difference in size between this and some of the latter, nor is there any reason to think that the arrangement of the papular pores can change from the condition characteristic of *Pectinaster* to that of *Cheiraster*, especially in specimens nearly of the same size.

Whether this species ever develops large spines on the disk, when older, I cannot say. I have seen none with such spines.

This species, as listed by Perrier, was taken by the Blake Expedition at about 42 stations (not all recorded by Perrier), nearly all were between 73 and 314 fathoms. One was taken in 805 fathoms, off Havana; one in 611 fathoms, off Dominica, station 175; one in 1,030 fathoms, off Martinique, station 196.

Although I studied a large number of specimens of this species in the Blake collection, I have no memoranda in respect to these three from great depths. Perhaps some of them may be distinct. Perrier himself makes no remark about either, except the first, from 805 fathoms, which he says is a large specimen without pedicellariæ. (Compare my *C. planus*.)

The Blake localities are nearly all among the Lesser Antilles. Three are in the Gulf of Mexico, off West Florida and Alabama, in 84 to 229 fathoms. I have no data sufficient to list all the

forms without discal spines separately, for Perrier did not designate them and I did not examine nearly all the lots.

The Albatross also took this species in many localities, in the same region. The type (No. 10,226 Nat. Mus.) was from 143 fathoms, off West Florida.

It was taken by the Bahama Expedition at station 2, off Havana, in 210 fathoms.

Among those listed by Perrier as *C. mirabilis* there were probably some of the following species:

PECTINASTER GRACILIS Verrill, sp. nov.

Plate vi; figure 1. Type. Plate xiv; figure 4. Plate xv; figures 1-1*b*.

Regularly stellate, with slender, tapering, depressed, acute rays. Radii of the type, which is probably immature, are 5^{mm} and 30^{mm}; ratio, 1:6; another of same lot has them 4^{mm} and 30^{mm}; ratio, 1:7.5.

The dorsal plates are roundish or elliptical, very unequal in size, somewhat convex, not crowded, nor closely tesselated. They bear a rosette of about six to eight very small clavate spinules, and most of the larger ones have a small upright, central spinelet, often as long as the diameter of the rosette; seldom twice as long. Near the tips of the ray the rosettes become minute and crowded, and the paxillary area very narrow.

The papular pores are five to seven on most of the rays. The primary central pore is larger than the others and is surrounded by about five to eight somewhat thickened and enlarged convex plates; usually two pairs are situated near it, one a little more distal and the other a trifle more proximal, and wider apart, or else in the same transverse line, so that they form either a trapezoid or rectangular figure, when regularly developed, but both in a pair may not appear at the same time; one or sometimes two, additional small ones appear on some of the rays, more distally, and sometimes a small pair more proximally. Thus it is probable that older specimens may have at least four pairs. Specimens slightly smaller than the type, in the same lot, have only three or four papular pores. Owing to the higher and thicker plates around the central and adjacent pores, the

papular area shows as a small convex or raised area, covered with paxillæ rather larger than those near by, and some of the plates may bear a central spinelet larger than usual. There are no larger central spines on the disk. The madreporic plate is small with few gyri; it is separated from the marginal plates by four or five rows of very small plates.

The jaws are relatively unusually wide and short, about as wide as long, convex, and laterally broadly rounded. The marginal spines are longer than usual, slender, divergent, not crowded, about six on the convex lateral margin, besides the apical or peroral one, which is larger and longer than the others, and acute. Each half of the jaw has about ten to twelve small spinelets, irregularly disposed, the two groups separated by a slightly prominent narrow carina, with no naked median sutural area.

The superomarginal plates have each a moderately long, slender, terete, acute spine. They are about equally spaced and pretty regularly graded, so that they form a very regular row. They have no secondary spines at the base. The rest of the plate is finely spinulose.

The inferomarginals also bear a similar marginal spine, without secondaries, their surface is covered with small, sharp, spaced spinules becoming very small at the inner end.

The adambulacral plates have a furrow-comb of seven or eight slender spines, continued around the actinal edges by several much smaller, slender, irregular spinules. The actinal face bears one (or sometimes two) rather long, slender, acute spines. About fifteen adambulacral plates correspond to ten inferomarginal plates.

The interactinal plates form a single chevron of about six spinulose plates. Only one or two rudimentary pedicellariæ are beginning to form on some of the areas. On specimens of the same lot, slightly smaller, there are only four interactinal plates and no trace of pedicellariæ.

In form, size and general appearance this species resembles *P. mixtus.* It can be readily distinguished by the dorsal plates, which are rounded and convex, while in the latter they are flat and closely tesselated, as well as larger; in this the jaws are

wider and their marginal spines and apical spines are fewer and much longer, and more acute; this also lacks the secondary spines below the inferomarginal one, which are a prominent feature in *P. mixtus* as well as in *Cheiraster echinulatus* and *C. mirabilis*. The arrangement of the papular pores and surrounding convex rounded plates is also characteristic.

Very common in the West Indies, in 70 to 300 fathoms.

The type (No. 10,564 Nat. Mus.) and cotypes were taken by the Albatross, but no station number is given. I have seen many others from the West Indies, in the Blake collection. The specimen figured on plate xv, figs. 1-1*b*, is from 126 fathoms, Antilles.

PECTINASTER OLIGOPORUS (Perrier) Verrill.

Pontaster oliogoporus Perrier, Exped. Trav. et Talisman, p. 293, 1894.
Archaster mirabilis (*pars*) Perrier, op. cit., p. 259, 1884.

The description given by Perrier (1894, p. 293) is very brief and mostly comparative, as to *P. limbatus* Sladen. The type and only specimen was young and came from station 143, Blake. According to Perrier its peculiarities are as follows:

He states that it is a typical *Pontaster*, with seven or eight papulæ united in a single group upon the median line, at the base of the rays, and says that according to Sladen's analytical key it would come next to *P. limbatus*,[25] but in the new species the jaws are less spinose: the adambulacral spines are ten to twelve, and form a complete circle around the plate, and the the papulæ, instead of being in longitudinal rows, are in two or three irregular transverse rows. Also, there are eight interactinal plates in a single row. There are no pedicellariæ of any kind.

The type of this species, which I have not seen, was a "unique" specimen from Blake station No. 143, in 150 fathoms, ooze and sand, off Saba Bank, N. lat. 17° 30′; W. long. 63° 42′ 35″.

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25 *P. limbatus*, with which Perrier compared his new species, has no large spines on the disk, it has numerous small secondary spines around the base of the large inferomarginal spine, and the under side of the inferomarginal plates is thickly covered with coarse acute spinules; the upper marginal plates encroach on the disk; the dorsal paxillæ have central spines; the adambulacral plates have two or three acute spines on the actinal face; the papularia are swollen, elliptical.

Pectinaster dispar Verrill, sp. nov.

Plate xiv; figures 1, 1*a*, 1*b*. Details.

The superomarginals are large and wide, encroaching on the paxillary area, thus forming a wide and thick border. They have wide and deep, fasciolated, oblique, sutural grooves. Each bears one large spine of moderate length, about equal in length to one and a half times that of the plate. The breadth of the plate is more than half that of the radial paxillary area proximally.

The paxilliform plates are mostly small, stellate, spinose protopaxillæ. They bear six to eight long and acute marginal spinules, and a longer central, erect, acute spine. Their radiating spinules are longer, fewer and more spine-like than in any of our other species. The papular pores form a small, central, transverse group, with about four larger pores on each side of the central one, without specialized plates.

The inferomarginal plates are large and broad and have their lower surface closely covered with rather large, short, stout, acute, conical spinules, that are appressed and almost imbricated in about six alternating rows. They are stouter and more conical than in any of the other species, but not so long as in *C. echinulatus.* They increase in size and length outwardly. These are followed by three or four larger, unequal secondary spines around the base of the large, stout, marginal one. Some of the secondaries are more than half as long as the large one. The grooves between the plates are fasciolated with slender interlocking spinules.

The adambulacral plates are large and prominent. The marginal edge bears a row of ten to twelve, or more, long slender graded spines. The rows are continued all around the margin of the plate by ten to twelve smaller and more slender spines. The actinal face bears two larger and very unequal spines. The larger one is very stout, conical, acute, not very long. The other is very slender, equally long, tapered, acute.

The type was from an Albatross station, locality unknown. (No. 18,468, Nat. Mus.)

Genus Luidiaster Studer.

Luidiaster Studer, Sitzungs. Naturf. Freunde, Berlin, xvi, pp. 130, 131, 1883; Anhang Abhandl. K. Preuss. Akad. Wiss., Berlin, pp. 49, 51, 1884. Ludwig, Notomyota, 1910, p. 451. Fisher, op. cit., 1911*b*, p. 127. Verrill, op. cit. p. 311, 1914.

Acantharchaster Verrill, Proc. U. S. Nat. Mus., xvii, p. 268, 1894. (Type, *A. dawsoni* Ver.)

Rays usually five, angular, tapered. Disk small. Interradial actinal plates few, confined to the disk, spinous and with pectinate pedicellariæ.

The dorsal surface is covered with small, unequal, thin plates, mostly in the form of protopaxillæ and spinose parapaxillæ.[1] The latter have a low, round column and bear a large, central, articulated spine surrounded at base by a circle of small spinules; they are found on the disk and usually along the median part of the rays. The protopaxillæ are smaller, and part of them bear only small spinules; others have a small central spine. The papulæ occur, in the adults, on most of the disk and entire basal part of the rays. Marginal plates of moderate size, more or less alternate, spiniferous; those of the upper series smaller than those of the lower, rounded, with a central eminence bearing a large, movable spine, sometimes with a group of small spinules around its base. The plates of the lower series may bear one or two large spines surrounded by spinules. There are no odd interradial marginal plates.

Large double-pectinate pedicellariæ are normally present on the interactinal plates or over their sutures in the adults, but may be partly or wholly lacking in the young. Similar pedicellariæ of smaller size and fewer valves may occur on the marginal and dorsal plates; rarely on the adambulacral plates.

The larger interactinal compound pedicellariæ may have ten to twelve or more incurved papillæ on each side, while those of the dorsal surface have usually three to six. The central dorsal pore is very evident and is surrounded by papillæ. The adambulacral plates have a salient inner angle, and bear a horizontal divergent group of slender furrow-spines and a transverse actinal row of long spines, two, three, or more; rarely one.

[1] See pages 84, 85, above, for these terms.

The jaw-plates are large and bear marginal and actinal series of slender spines.

The bilobed papularia often form a rather diffuse group on the basal part of the ray and on the disk; the two halves are separated by the median row of plates between which papulæ do not often occur. The papularia are not swollen. In the adult the papulæ may be very numerous; few in the young.

The dorsal muscular bands, in the few species examined, are attached proximally to a crest-like process of two ambulacral plates, as well as to the inferomarginals. Professor Fisher thinks this is a constant generic character. Other than this there are no definite or precise characters to distinguish this genus from *Cheiraster*. It may eventually be necessary to reunite them, under *Cheiraster*.

Personally I have not seen any West Indian species that can be referred with certainty to *Luidiaster*.

The description of the genus is given here mainly for the sake of comparison with *Cheiraster* and *Pectinaster*, but also because one of the above species (*P. vincenti*) has been referred to it by Ludwig.

The new species, *Cheiraster enoplus*, described above, has the outward appearance of *Luidiaster*, and may eventually prove to belong to that genus, when its dorsal muscles can be studied. At present it is better to leave it in *Cheiraster*, for it has all the external characters of the latter.

Suborder PAXILLOSA (Perrier, emended).

Perrier (as an order), Exped. Traiv., pp. 28, 192, 1894. Verrill, Trans. Conn. Acad., x, pp. 199, 200, 201, 1899; op. cit., 1914*a*, p. 314. Fisher, 1911*b*, p. 19.

These are Phanerozona in which the two rows of marginal plates are usually well developed and often spinose, (in *Luidia* only the lower are well developed). They usually have well marked fasciolated grooves between them, to convey water for respiration. The dorsal or abactinal plates are usually developed in the form of true, columnar paxillæ or spinopaxillæ; sometimes as parapaxillæ or pseudopaxillæ. Pedicellariæ are often present, usually consisting of several connivent papillæ,

or spinule-like structures, on a plate, often surrounding a pit or pore. Sometimes two-bladed forceps-like forms occur.

Bivalve valvular pedicellariæ are lacking. Ambulacral feet are generally pointed; sometimes flattened and natatory; rarely with a small terminal knob, but without a sucker.

Ambulacral ampullæ are usually double; single in *Luidia*, *Ctenodiscus* and allies. Dorsal pore present or absent. Superambulacral plates are usually present; sometimes absent.

The Paxillosa should only include such groups as do not have true bivalve pedicellariæ nor sucker-feet. The existence of true paxilliform plates on the dorsal surface cannot be made an invariable diagnostic character, for they occur in some forms of Valvulosa. The development of the ambulacral feet varies much in both groups, and probably depends more on the nature of the bottom anciently inhabited, than on the habits of existing species.

The gonads are commonly a single pair in the proximal part of the rays, but in *Luidia* and several deep-sea genera of Astropectinidæ there is a series along each side of each ray, (multiple gonads.)

The papulæ are confined strictly to the dorsal surface and often to limited or definite radial areas. They are generally simple and stand singly between the dorsal paxillæ, protected by the fascioles. In *Luidia* they become branched.

In *Leptychaster antarcticus* the eggs and developing young are carried between the dorsal paxillæ, and the young, of some size are attached to the dorsal surface. Some genera are known to undergo a complete metamorphosis, having free swimming larval stages (brachiolaria, etc.) The embryology of most of the genera is unknown.

Family Astropectinidæ (restricted.)

Astropectinidæ (*pars*) Gray, Ann. and Mag. Nat. Hist., p. 140, 1840; Synopsis, p. 2, 1866. Sladen (*pars*), Voy. Challenger, xxx, p. 174, 1889 (includes *Luidia*). Perrier, op. cit., 1894, p. 193 (*pars.*)

Astropectininæ Sladen, op. cit., 1889, p. 175.

Astropectinidæ (sense ext.) Fisher, op. cit., 1911*b*, p. 37, (Analytical table of all recognized genera). Verrill, op. cit., 1914*a*, p. 314.

Paxillosa in which the disk is usually small or of moderate size. The rays are often much elongated. The dorsal surface is

generally covered with highly developed true paxillæ (sometimes with parapaxillæ or pseudopaxillæ), covering fasciolated interspaces, lodging intervening simple papulæ.

Marginal plates of both rows are usually large, thick, and paired. The inferomarginals are often the larger transversely. They are either granulated or spinulose and often very spinose, with more or less simple fasciolated grooves between them, but never covered by a thick skin. Adambulacral plates are usually spinose or spinulose on the actinal surface and have a divergent row of furrow-spines, without a web.

Pedicellariæ are often lacking; when present they are usually fasciculate or papilliform, often consisting of two to four short, slender, connivent spinules, surrounding a special pore or pit. Ambulacral feet in two rows, large, usually pointed, never with suckers. Ampullæ double. Dorsal glands and pore usually present. Superomarginal plates always present.

Interactinal plates sometimes wanting; often more or less numerous and arranged in regular rows; usually spinulose and with fasciolated grooves between the rows, but without marginal webs; fascioles are sometimes lacking.

The aproctous condition, formerly supposed to be characteristic of the family, is unreliable, for in nearly all the genera referred to it there is a perfectly well defined dorsal or "anal" pore, and in some of the genera the pore is even elevated on the summit of a dorsal cone or chimney (*Psilaster, Ilyaster*, etc.) This pore, which I have designated as "*pseudanus*" or "*nephridial pore*," serves in this family (and in many others) chiefly if not entirely, for the discharge of the secretions of the lobulated dorsal gland (probably nephridial in function.)

Genus Astropecten Gray (emended).

Astropecten (*pars*) Gray, Ann. and Mag. Nat. Hist., vol. vii, p. 180, 1840; Synopsis, p. 3, 1866. Müll. and Trosch., Syst. Aster., p. 67, 1842. Sladen, op. cit., 1889, p. 193. Fisher, op. cit., 1911*b*, p. 55. Verrill, op. cit., 1914*a*, p. 317.

Stellaria Nardo, Oken's Isis, p. 716, 1834, (*non* Müller, 1832, Mollusca).

Asterias L. Agassiz, Prod., p. 191, 1835.

Rays more or less elongated, subacute, flat above, with true, abactinal, coronate or stellate paxillæ, and large, stout, paired and fasciolated marginal plates. The superomarginals are con-

vex, encroaching more or less on the upper side of the disk and rays. They are often entirely granulose, sometimes spinulose, and often have one or two superior spines or tubercles. Inferomarginals spinulose and spinose, prolonged actinally, most of them reaching the adambulacral plates, but one or two interradial pairs may not reach the adambulacral plates, and in that case one or two pairs of small adoral interactinal ossicles may intervene, but these do not form regular rows, nor an important triangular area.*

The inferomarginals bear marginal spines and are closely spinulose and fasciolated laterally. Adambulacral plates are equal in number to the inferomarginals; the inner end is angular. They have a longitudinal group of about three, rarely four, furrow-spines, and two transverse rows, or a divergent group, on the actinal side, often with the central or aboral spine enlarged. The papulæ stand singly around the dorsal paxillæ; they are generally absent along the median line. Dorsal pore often indistinct or lacking; sometimes present. Superambulacral plates are well developed. Pedicellariæ are generally lacking; sometimes they are present on the adambulacral plates, and then are papilliform, with two, three or more valves. They sometimes occur also on the dorsal paxillæ and on the superomarginal plates.

The madreporic plate is commonly concealed by the dorsal paxillæ; in some species it is exposed.

Species of *Astropecten* are very numerous and have been found in all tropical and warm-temperate seas in suitable localities. They live mostly on sandy or muddy bottoms, in rather sheltered localities, when in very shallow water, but on the open sea bottoms when in water deep enough to be beyond the active action of the waves.

They customarily live buried just beneath the surface of the sand, keeping up a free communication with the water for respiration by means of currents drawn through the fasciolated grooves by ciliary action. But they can also live exposed, and can glide along quite rapidly by means of their large, muscular, ambulacral feet.

They are most numerous in depths of 10 to 60 fathoms, but

* Certain species having a notable group of interactinal plates were made a separate genus, *Astropectinides*, by me (1914*a*, p. 321).

are often found in 100 to 200 fathoms. Very few species are found at great depths. The Challenger Expedition took only three species in depths greater than 350 fathoms. The deepest was in 450 fathoms. The Albatross, in the Pacific off Panama, apparently took one species, *A. exiguus,* in 2,136 meters (Ludwig), but there is some doubt as to the correctness of the label. It also occurred in much shallower water. The West Indian species, so far as known, all occur in less than 150 fathoms, and most of them in very shallow water.

The species of *Astropecten* are apt to be variable in many of their characters, regarded as specific, and therefore their synonymy is often complex. The number and size of the superomarginal spines are variable, not only with age, but independently of it. Species that normally have spines may sometimes occur without them. These spines are often undeveloped in the young, when of considerable size, when they would appear later. The different rays of the same specimen may differ as to the size, number, or partial absence of spines.

Variations in the inferomarginal spines are also frequent, both as to size and shape. All of our species except *A. braziliensis* normally have two to a plate, but three spines often occur on some plates in certain species. None have more than three, as do some foreign species. Dorsal paxillæ vary considerably, in some species, but in general are fairly constant.

Perhaps the most constant specific characters are to be found in the spines of the adambulacral plates, yet these vary to some extent.

Our West Indian species have three spines in the furrow-series and nearly all have two unequal, usually flattened, spines in the second (middle) series, with the aboral one larger. But a few of our species have two or three slender and nearly equal ones in that row.

This is, perhaps, the most available character for dividing them into two principal groups (see table below).

The West Indian species, like most others, are mostly destitute of pedicellariæ, or have one or two rarely, but *A. americanus* often has a nearly continuous series, of rather large size, on the adambulacral plates. The same is true of some specimens referred to *A. nitidus v.*, under the varietal name *forcipatus.*

Other specimens, almost identical in other respects, lack the pedicellariæ, or have very few.

The most distinct or most divergent species in our fauna, is *A. americanus*, a form exceedingly abundant off the middle Atlantic coast of the United States, in 40 to 150 fathoms.

This not only has abundant pedicellariæ, but it is peculiar in many other ways. The dorsal paxillæ have unusually long slender spinules; the marginal plates are spinulose, instead of being granulose, as in most species and the adambulacral spines are all slender, a feature not found in most species. The superomarginal plates are concave transversely in the middle and thickened near the margins, a peculiarity not found in any other species known to me.

In the West Indian fauna there are now recognized eleven species, besides two or three named subspecific or varietal forms and two or three doubtful or insufficiently described species.

The character of the superomarginal spines, although a conspicuous feature is too variable to be of primary importance in grouping the species. Moreover, if classified by this as a primary feature, closely related or even varietal forms may be widely separated, and very diverse, species brought together. The following lists may, however, be of some use in the approximate location of adult specimens.

A. Species having two rows of spines on the superomarginal plates at least proximally: *A. duplicatus; A. antillensis; A. braziliensis.*

B. Species having one row of superomarginal spines or tubercles; rows often incomplete: *A. articulatus; A. alligator; A. nuttingii.*

C. Species having no superomarginal spines or tubercles: *A. comptus* Ver., nov.; *A. americanus* Ver.; *A. americanus subgracilis* Ver., nov; *A. richardii* Perrier; *A. cingulatus* Sladen; *A. articulatus dubius* (Gray); *A. nitidus* Ver., nov.; *A. nitidus forcipatus* Ver., nov.; *A. ciliatus* Grube.

Analytical Table of West Indian Species of Astropecten.

A. Adambulacral plates have one or two notably enlarged spines in the second row. Few or no pedicellariæ.

B. Superomarginal plates have, in the adult, one or two rows of spines.

C. Superomarginal plates have only one row of spines.

D. Dorsal marginal spines small, placed on the outer curvature of the plates, most developed distally, seldom reaching the second basal plate. Superomarginal plates large and thick, well rounded above, closely granulated. Fasciolated grooves wide. Adambulacral spines mostly flattened; the two in the second series much at and mostly spatulate or trimcate, aboral and much the larger; those of furrow-series compressed, elongated.

A. articulatus (Say).

DD. Dorsal marginal spines largest on the first two basal plates, which are larger and higher than the next plates.

A. duplicatus Gray (Young).

CC. Superomarginal plates have two rows of spines proximally.

E. Inferomarginal spines mostly two or three to a plate. Superomarginal plates not unusually numerous, about 20-30, large, advancing considerably on the disk and rays; basal ones broad and swollen above surface with close, short granules. Paxallar area not very wide, about twice width of marginal plates. Inferomarginals project laterally notably beyond upper plates and have two marginal spines. Rays of moderate length. Dorsal paxillæ crowded, not forming regular transverse rows.

F. Inner adambulacral spines large and stout, compressed; two in median row very unequal; aboral and large and stout, flat, trimcate. Dorsal paxillæ coronate, with short clanate or capitate spinules; central ones similar. *A. duplicatus* Gray.

F. Paxillar area bears many spinopaxillæ.

Var. *variabilis* (Ltk.)

FF. Inner adambulacral spines three, all slender, divergent; two in second series unequal; aboral one obtuse, large and stout, not very flat nor spatulate. Dorsal paxillæ stellate, with the spinules slender and acute; central one erect.

A. antillensis Lütk.

EE. Inferomarginal spines mostly one on each plate. Superomarginal plates unusually numerous, (48-50), proximal ones high, narrow and angular above, proximal ones not notably enlarged; surface with spinules or elongated spaced granules, distinctly larger and longer around bases of spines; fasciolated grooves deep and narrow; spines of proximal plates elongated,

acute. Disk rather wide; paxillar area at base of rays wide, about four times as wide as the narrow marginal plates; the paxillæ are small and even, regularly arranged in transverse rows on rays; their spinules are clavate or capitate. Inferomarginals scarcely project beyond upper ones laterally; their marginal spines long and acute. Inner adambulacral spines long, rather slender; two in second row very unequal; aboral one notably large and stout, not flat, subacute or obtuse.

A. braziliensis M. and Tros.

BB. Superomarginal plates in adults are destitute of marginal spines or tubercles.

G. Superomarginal plates in adult are unusually numerous, (46-48) much higher than long, large, rectangular, evenly rounded, vertically, compactly granulated, separated by narrow fasciolated grooves; proximal pairs larger, more convex. Paxillar area wide, proximally about three times as wide as marginal plate. Paxillæ small and even, coronate, crowded, not in obvious rows; their spinules are short, capitate numerous. Inferomarginal plates do not project laterally beyond upper ones; marginal spines are large, mostly acute. Adambulacral spines are numerous, nearly all flat, often forming four rows of about three each; three in second row are flat and truncate; two aboral little larger, subequal. *A. comptus*, sp. nov.

GG. Superomarginal plates not unusually numerous, usually less than 25; large, encroaching on the upper surface.

H. Superomarginal plates not unusually broad, about 25 to 30, granulated, not more than about half as wide as the paxillar area, proximally; fasciolated grooves wide and deep. Marginal spines of inferomarginals stout and flattened. Adambulacral spines, strong, flattened; two in second series, truncate, unequal.

h. Dorsal paxillæ do not form obvious transverse rows on the rays; their spinules are subequal, short, capitate or granule-like.

A. articulatus dubius (Gray).

hh. Dorsal paxillæ form regular transverse rows on the rays; their spinules are numerous and unequal, the central ones larger, so that the outlines of the paxillæ are defined.

A. richardi Perrier.

HH. Superomarginal plates about 19, large, unusually broad, the breadth exceeding the length; proximally about as wide as

the narrow paxillar area, or wider, compactly granulated. Inferomarginal spines two, small, slender, acute; lower side of plates covered with short, flat spinules, and with an aboral series of small spines. Adambulacral spines small, triseriate.

A. cingulatus Sladen.

AA. Adambulacral spines of second row not notably enlarged, nor very unequal; all rather slender; one sometimes longer.

I. Superomarginal plates have a row of small spines, at least proximally, in adult.

J. Adambulacral spines few and slender; superomarginal spines confined to the proximal plates; outer surface of plates granulated. *A. alligator* Perrier.

JJ. Adambulacral spines triseriate, in three regular rows of three each; all slender; outer ones very slender. Superomarginal spines form a continuous row to tip of rays, slender, acute; the plates are narrow and high, covered with elongated granules or short spinules. Inferomarginal plates project beyond the upper ones; the two marginal spines are slender, acute; lower surface covered with small spines of various sizes, not limited to two rows, and with small acute spinules between them.

A. nuttingi Ver., nov.

II. Superomarginal plates are destitute of spines or tubercles. Dorsal paxillæ form transverse rows on the rays: Inner adambulacral spines slender, three distally, often four proximally. Pedicellariæ often present.

K. Superomarginal plates transversely convex and closely granulated. Dorsal paxillæ form transverse rows and have short capitate or clavate stellate spinules. Inferomarginal plates have two slender, acute spines, or often three proximally; lower surface with two irregular rows of small acute spines and covered with minute, slender, acute spinules.

L. Adambulacral plates have proximally three to five rather long, slender spines in inner series; three to five more slender in a row in second series; and usually three or four still more slender in outer series. Few or no pedicellariæ on adambulacral plates. *A. nitidus* Verrill, nov. Typical.

LL. Adambulacral plates have, at least in part, a large pedicellaria, usually with three slender valves, on the actinal side, re-

placing part or all of the spines of the second, or sometimes the third, series. Other characters as in typical *nitidus*.

A nitidus, var. *forcipatus* Verrill, nov.

KK. Superomarginal plates are flattish or even a little concave transversely, and covered with small spaced spinules. Dorsal paxillæ small, high, openly arranged in spaced rows; their spinules are few, long and very slender. Inferomarginal plates project laterally beyond upper ones, and have two slender, very acute marginal spines, sometimes with a small pedicellaria above the base of each; under side covered with numerous slender, acute spines and spinules of various sizes, the spines not limited to two rows. Inner adambulacral spines very slender, mostly three, but often four or five proximally; second series has four or five slender spines or else a large, usually three-valved pedicellaria replacing most or all of the spines; third series has about three or four slender spines and sometimes a pedicellaria.

A. americanus Verrill.

kk' Disk smaller; rays more slender; paxillæ smaller; adambulacral pericellariæ larger, more often four-valved.

Var. *subgracilis* Ver., nov.

KKK. Inferomarginal spines two, flattened, with about three small spines below base. Adambulacral spines eight on actinal face, sometimes one longer on the center. Marginal plates 40-42.

A. ciliatus Grube.

Astropecten articulatus (Say) Müll. and Trosch.

Asterias articulatus Say, Journ. Acad. Nat. Sci., Philad., vol. v, p. 141, 1825.

Astropecten articulatus Müll. and Trosch., Syst. Aster., p. 72, 1842. Lütken, Vidensk. Meddel., 1864, pp. 128, 129 (description). Verrill, Notes on Radiata, Trans. Conn. Acad., i, p. 343, 1868 (distribution); Radiata of North Carolina, p. 438. Perrier, Revision, Arch. Zoöl. Exper. et Gen., vol. v, p. 290, 1876 (not described). A. Agassiz, North American Starfishes, p. 114, pl. 19, figs. 1-8, 1877 (details of structure.) Verrill, Expl. by the Albatross in 1883, pp. 40, 77, 1885; Distribution of Echinoderms, p. 133, 1895. Ives, Echinoderms Bahama Islands, Proc. Philad. Acad. Sci. for 1891, p. 337, pl. xvi, figs. 4-8 (includes a translation of Lütken's description.) Clark, Echinoderms of Jamaica, p. [4], 1898.

Astropecten dubius Gray, op. cit., 1840, p. 182; Synopsis, p. 4, 1866 (variety).

Diagnosis: This common species, in its normal adult form, has a rather thick disk and robust rays, with large, thick, stout

superomarginal plates, which are evenly rounded vertically, densely granulated, and separated by deep and wide fasciolated grooves, clothed with innumerable fine spinules. On the distal half to three-fourths of the ray these plates bear, on the outer convex surface, a single small obtuse-conical spine. These spines rarely extend to the base of the ray. Paxillar spinules are crowded and capitate or clavate.

Inferomarginal plates bear two flattened, short, marginal spines, side by side, and a row of about four on the under side, near each margin, the aboral ones larger; between these the surface is closely crowded with small, flat, more or less scale-like spinules.

The adambulacral spines are triseriate or nearly so; inner ones are usually three, somewhat flattened; the next row has two flat spines, side by side, the aboral one larger. Sometimes there is a third spine; outer ones are four to six, small, flat, or spatulate spinules, either in one or two rows, or clustered.

Special description: A well grown normal specimen agreeing well with Say's type, is from Egmont Key, W. Florida (No. 2213, Yale Mus.).

Its radii are 17^{mm} and 76^{mm}; ratio, 1:4.5; breadth of rays at base, without spines, 20^{mm} with spines, 25^{mm}; breadth of paxillary area at second pair of superomarginal plates, 10^{mm}; breadth at 10th pair, 8^{mm}; radius of disk is equal to first six or six and one-half marginal plates; height of second marginal plate is equal to length (radial) of three (2d to 4th). Number of marginal plates, 27-28 pairs.

The rays are thick and stout with rather blunt tips. The ocular plate is relatively large, turned up, short and thick, as wide as long, deeply bilobed, and grooved above with the sides swollen. Paxillary area broad, even.

The superomarginal plates are larger, and thick, well rounded transversely, not at all obliquely placed, except slightly near tip of rays. The first or interradial pairs are thicker and higher than the following, and wedge-shaped.

A single imperfect row of small, short, obtuse-conic or acorn-shaped spines is present on the distal two-thirds or three-fourths of the ray, extending on some of the rays to the fifth plate from the base, and to the last pair of plates at the tip of the ray.

These small spines are situated on the outer or descending curvature of the plate. Small, regular, rounded, closely-packed granules cover the rest of the outer surfaces of the plates, but the sides in the fasciolated furrows are densely covered with very slender, elongated spinules, much finer than the granules. The grooves between the plates are wide and deep.

The dorsal paxillar area is nearly even. The paxillæ are closely packed, stellate; those along the middle are quite as large as the lateral ones. Each of the larger ones bears about six to eight divergent, marginal, short, clavate or capitate spinules, surrounding one, or sometimes two, of the same size and form. At the very center of the disk there is a small area of much smaller and finer paxillæ, on a slight elevation.

The madreporic plate is partially visible, closely surrounded by the normal paxillæ; it is not far from the marginal plates.

The inferomarginal plates bear two nearly equal, stout, slightly curved, marginal spines, side by side. On the proximal half of the ray these are much flattened, lanceolate or oblong lanceolate with rather acute tips; those in the interradial angle are shorter and flatter; those beyond the middle of the ray are less flattened and more acute. The longest are scarcely equal in length to the radial length of two of the adjacent superomarginal plates.

Extending downward from the outer of these spines, and bordering the aboral margin of the plates there is a spaced row of about five smaller, flattened, usually appressed, acute spines; the upper one, close to the base of the marginal, is about half as long as the latter; the others decrease gradually in size. Another less marked row of similar but smaller spines borders the adoral margin of these plates. The rest of the outer surface is closely covered with small, flat, blunt, mostly short, scale-like, imbricated spinules. These are often as wide as long.

The adambulacral plates, when well developed, have a furrow series of three rather stout, flat, truncate, divergent spinules; toward the mouth there are often four spines. These are nearly equal in size, but the middle one is slightly longer and vertically compressed, and is seated on the slightly prominent angle of the plate. The others are thin and slightly wider near the distal end. Back of these, on the actinal side, are two flat, truncated,

unequal spines side by side; the larger one is on the aboral side of the plate, and similar in form to the outer of the furrow-spines, but somewhat larger; the smaller one is more spatulate at the tip, and not quite so long. The outer end of the plate bears a marginal group of five to seven, most often six, small, spatulate, divergent spines, which often form a stellate group, but in other states of preservation seem rather to form two radial rows of about three each, not very regularly placed. Rarely a short ovate pedicellaria replaces part of these spinules.

The peroral spines are numerous and rather stout; epioral are very numerous and crowded, small, spatulate and flat at the tip. Color of the dry specimen yellowish brown. The colors, in life, are variable. It is often orange. It may be purplish on the paxillar area, orange-red on the superomarginal plates, with the marginal spines purple, and lower surface yellow.

Variations.

This is known to be a variable species. The superomarginal plates vary in prominence and size, and their small conical spines may be reduced to tubercles, and disappear irregularly on more or less of the distal plates, or even be entirely lacking. In other cases they extend to the interradial plates.

The marginal spines of the inferomarginal plates may be less flattened, and more acute than in the one described above, especially on young specimens. The flat, scale-like spinules of their lower surface may be less flat and more slender. The inner adambulacral spines, in the young, may be much more slender and less flattened, and the same is true of the outer ones. Pedicellariæ, of rather small size, occur rarely.

The young. A young specimen from off St. Martine Reef, West Florida (No. 16,322, U. S. N. Mus.) with the radii 10^{mm} and 30^{mm} has all the essential characters of the adult, but the small dorsal marginal spinules are not developed on the first five or six plates. Center of disk has a low cone.

A still younger specimen (No. 16,324, U. S. N. Mus.) from Cape Romanes, Fla., has most of the characters of the adult. Its small dorsal marginal spines extend, on most of the rays, to the fourth proximal plate.

There is a central conical elevation of the disk, with a minute

dorsal pore at the apex. Radii 9^{mm} and 28^{mm}, marginal plates 17-18 on a side.

Teratology.

A medium sized specimen taken on the Great Bahama Bank by the Bahama Expedition, May 17, is quite unlike any other that I have seen, in some respects. The radii are 14^{mm} and 53^{mm}; breadth of rays at base, minus spines, 15^{mm}; breadth of paxillar area at 2d marginal plate, 4^{mm}. Number of superomarginal plates 17 to 18 pairs. The marginal plates are unusually large and thick, well rounded, rising up considerably above the narrow paxillar area and separated by wide, straight, fasciolated grooves. The radius of the disk is equal to five marginal plates. The two interradials are particularly large and swollen, except in one interradius where they are narrower and separated partially by an *unpaired* intercalated plate, bearing a small conical spine. Small conical spines are present on the outer side of more or less of the plates on the distal part of the rays, but are entirely lacking on some distal plates, but they extend proximally in some cases to the second plate and on one side of one ray to the first plate, which bears also a second similar spine at the summit. A few other short spines of the inner series occur on the first and second plates, thus approaching the condition seen in *A. duplicatus*, but these spines are few, small, and irregular on this specimen. The inferomarginal spines are flattened, as in the type, mostly two, but proximally three, subequal, on many plates.

The spinulation of the under side, including the adambulacral plates, is essentially the same as in the typical specimen of *A. articulatus*, described above.

Mr. Ives (op. cit., 1891) stated that the species described by Lütken and that figured by A. Agassiz, as *A. articulatus*, are different, and that the latter represents *A. duplicatus* Gray.

I do not agree with either of these propositions. The general figures by Agassiz accurately represent the species found on the coasts of North Carolina and Florida, when in perfect preservation, and agree entirely in all essential points with the descriptions by Say and Lütken, even to the row of small conical superomarginal spines on the distal part of the rays only — a characteristic feature mentioned both by Say and Lütken.

When picked up on the beaches, or when poorly preserved, its appearance is much altered, aside from its ordinary variations, which are considerable.

On the other hand, the *A. duplicatus* of Gray, as determined by Perrier, after an examination of the types, is the same as *A. variabilis* Lütken. It is characterized by the presence of a *double row* of superomarginal spines, largest *proximally*, and is, in fact, the *most spinose species* of the West Indian fauna, and therefore quite unlike the figure by Agassiz.

For the same reason reference of Gray's (well named) *A. dubius* to *A. duplicatus* is evidently wrong, for Gray placed it in his group having no superomarginal spines. It may well be merely the not uncommon variety of *A. articulatus* in which the small superomarginal spines are obsolete or undeveloped.

Perrier stated, 1875, that he had examined cotypes of Lütken's species. He also states that in some of his specimens the upper marginal plates were entirely destitute of spines.

This species is common on sandy bottoms, in shallow waters, on the southeastern coasts of the United States, from Beaufort, N. C., to the Florida Keys, and on the western coast of Florida, north to Egmont Key and Tampa Bay.

It has been stated by A. Agassiz that it has been found on the coast of southern New Jersey, but I have seen none from that district. It needs confirmation. It ranges to Yucatan (Ives), and from the Bahamas to the Lesser Antilles. Dominica I. (A. H. Verrill). Many West Indian localities are doubtful because several authors have confused this with other species. Kingston Harbor, Jamaica, near Port Royal, in very shallow water on sandy bottoms, near or among mangroves (H. L. Clark). West Florida, near St. Martine Reef (U. S. Nat. Mus.).

Taken by the U. S. Fish Commission, at several stations off the Carolina coasts and Cape Hatteras, as far north as 35° 42′ N. lat. It occurred there in 4 to 43 fathoms, 1883 to 1885. Also off W. Florida, 27 to 88 fathoms.

It was taken by the Bahama Expedition, on the Great Bahama Bank, in shallow water. The Yale Museum has specimens from Egmont Key, W. Florida (W. T. Coons, No. 2213).

Astropecten articulatus dubius (Gray).

Astropecten dubius Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 182, 1840; Synopsis, p. 4, 1866.

Gray gave a very brief diagnosis of his species. He placed it in a section of the genus destitute of spines on the superomarginal plates. Otherwise he only states that the marginal plates are rather broad and granulated; the inferomarginals do not project beyond the upper ones, and their marginal spines are broad and depressed; the rays are broad and tapering.

These characters, so far as they go, all apply to the form of *A. articulatus* which lacks superomarginal spines.

Perrier places *dubius* as a synonym of *articulatus* without comment. He does not say whether he had seen the type, but he mentions spineless examples of *A. articulatus*, as others have done, and such as I have personally examined. Therefore, I propose to retain the name *dubius* for this form or variety of *articulatus*. It agrees with the latter in all respects, except in lacking the small dorsal spines.

It has apparently the same range as the typical form. I have seen specimens from Florida and the Bahamas.

Astropecten duplicatus Gray.

Astropecten duplicatus Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 185, 1840; Synopsis, p. 3, 1866. Perrier, Arch. Zoöl. Exper. et Gen., vol. v, p. 271, 1876 (no description.)

Astropecten valenciennii Müll. and Trosch., Syst. Aster., p. 68, 1842, (t. Perrier, from type.)

Astropecten variabilis Lütken, op. cit., 1859, p. 51, described. Verrill, op. cit., 1867, p. 343. A. Agassiz, Bull. Mus. Comp. Zoöl., i, 1869 (not described.)

Plate xvi; figures 2, 2*a*. Details of variety *variabilis*.

Plate xxii; figure 2. Plate xxiii; figures 1, 2.

This is the most spinose species of the genus found in the West Indian fauna. The only good description published is that by Lütken, 1859, which is in Danish, except a brief Latin diagnosis. That of Gray is an imperfect diagnosis, three lines long, not sufficient to distinguish it from several other species. It has never been figured, so far as I know, although it is a common

species. Hence there is considerable confusion as to the names.

Perrier stated (1876) that he had examined the types of Gray and of Müller and Troschel, and a cotype, sent by Lütken, of his *variabilis*, and had found them all identical. Therefore the name given by Gray must be adopted. But Perrier gave no description of the species, except a translation of part of that of Müller and Troschel.

Special description: A well-grown specimen, before me, seems to be the fully developed and normal form of this species. It is from the Albatross station 2407; N. lat. 28° 47′ 30″, off W. Florida, in 24 fathoms. (No. 10989, Nat. Mus.)

The radii are 14^{mm} and 74^{mm}; ratio, 1:5.3; breadth of rays at 2d marginal plate, without spines, 15^{mm}; radius of disk is equal to the radial length of five and a half basal marginal plates. Superomarginal plates are large and high; 25 on each radial margin.

The rays are angular, regularly tapered to narrow tips, high on the sides at base. The inferomarginal plates project, on the sides of the rays, beyond the upper ones, forming, with the lower ends of the latter, a lateral fasciolated furrow, covered with fine spinules.

The superomarginal plates are thick vertically with the outer side rising rather steeply, and the top, especially the first two pairs, prominent above the paxillar area. On the first seven plates there is a short, stout, tapered, acute spine, seated on the top of the plate and thus forming a short inner row. These spines are larger on the first two plates, decreasing to small short spines on the seventh.

An outer series of similar spines commences on the third plate and extends to the end of the ray, decreasing regularly. The surface of the plates is closely covered with short rounded granules, larger around the base of the spine, and grading into fine, short, crowded spinules in the fasciolated grooves, which are narrow and beyond the middle of the rays, distinctly oblique.

The inferomarginal plates bear two, or often three, rather short, flattened, subacute or acuminate spines; on the lower side there is along each margin a row of three or four unequal, flat, somewhat appressed spines, and between them the surface is covered thickly with rather coarse, elongated, somewhat flat and

mostly blunt spinules, which are not appressed. Thus the lower surface appears unusually rough and spinose.

The adambulacral plates bear an inner group of three compressed, rather slender spines on the prominent inner angle; the median one, which stands farther in, is curved and larger than the others. Outside of these there are two very unequal spines, nearly side by side; the adoral one is large, stout, a little flattened, subtruncate, and much longer than the other, which is usually flat and slightly spatulate. Sometimes a second small one stands by its side. External to these there is a row of three or four slender spinules. There is a small group of three or four small, spinulated, interactinal plates.

The dorsal paxillæ are rather large, regularly stellate, and when the spinules are extended they interlock and cover the surface closely, but the spinules are often folded up in a compact fascicle, exposing the large papular pores. Their spinules are rather long, clavate or capitate; about eight to ten marginal ones surround one, or less frequently two or three central spinules of about the same form and size, or a trifle larger, but not spiniform. At the bases of the rays and on the adjacent parts of the disk they become larger, and many have four to eight central clavate spinules and twelve to sixteen around the margin. The radial paxillæ do not form regular transverse rows, but about ten to twelve can be counted across the ray proximally. They are as large along the middle of the rays as laterally. A few very small ones surround the minute dorsal pore.

Madreporic plate is nearly concealed by the paxillæ. Ocular plate is narrower, longer, less swollen, and less deeply bilobed than in *A. articulatus*.

Variations.

This species is decidedly variable, as shown by Lütken, and well deserves the name he gave it.

A well-grown specimen from Florida (No. 259, Yale Mus.) otherwise normal, is peculiar as to its dorsal spines. On some of the rays several of the proximal plates carry three or four small spines, and in one case the first plate has six such spines, while its mate has only three. On some of the other rays both have but one spine. These additional spines have mostly been produced

by the enlargement of the larger granules that ordinarily surround the bases of the spines, and may be due to repair of injuries.

Inferomarginal plates have, in part, three acute marginal spines; there are about ten acute spines on the under side, and the intervening spinules are slender and semierect, not flattened. Radii 11^{mm} and 60^{mm}. Marginal plates 26 on a side. Madreporic plate is partly visible. No pedicellariæ.

According to Lütken's diagnosis the essential characters of *A. variabilis* are as follows:

Radii 11^{mm} and 52^{mm}; ratio, 1:4.7; breadth of ray, 13^{mm}.

Superomarginal plates large, with large biseriate or triseriate spines, often two or three to a plate. On the proximal plates of the rays there are commonly three large ones.

Inferomarginal plates are covered with somewhat large flattened secondary spines and spinules. Adambulacral spines triseriate; those of the inner row three, compressed; two in the middle row, of which the aboral one is larger and compressed; outer or third series minute.

On plate xxiii I have figured two specimens from St. Thomas I., sent by Professor Lütken, as cotypes of his species, called *A. variabilis.* They differ considerably in the characters of the dorsal paxillæ and the marginal spines, though they agree in general appearance and in most other respects. When compared with ordinary Florida specimens of *A. duplicatus* the rays appear narrower, the marginal plates higher, and their spines larger, while the paxillar areas appear narrower and more sunken below the level of the marginal plates, yet in most details of structure they agree very well.

These two specimens, although from the same place, differ widely in the structure of the dorsal paxillæ and in some other respects, so that they might well be considered local varieties if found in different localities. They may have come from different environments or different depths, not indicated on the labels. These and other variations were noticed by Lütken.

The specimen figured on pl. xxiii, figure 1, is nearly like the more ordinary or normal form described above. It has radii 11^{mm} and 50^{mm}. The disk and radial paxillary areas are narrower than in the other. The paxillæ mostly lack a central enlarged

spine, and have the form of ordinary paxillæ, the central spinule being short, clavate, like the rest, unless a trifle larger.

The surrounding stellate spinules are shorter than in the other, clavate, with blunt tips, so that the paxillæ appear smaller. On some parts of the rays they are arranged in evident transverse rows, toward each margin.

The inferomarginal spines are smaller and not so much enlarged or flattened. The secondary spines and the spinules of the under side are nearly the same in both, as are the adambulacral spines.

This specimen may be considered as representing the common or more typical form of the species.

Variety VARIABILIS (Lütken).

The specimen figured on pl. xxiii, fig. 2, and of which the structural details are figured on pl. xvi, figures 2, 2*a*, differs so much from the typical form that it may well receive a varietal name. This I propose to give by restricting Lütken's name to this form, which is one of those that he particularly described.

The radii are 11^{mm} and 48^{mm}.

The superomarginal spines are large, flattened and expanded distally and subtruncated or obtusely lanceolate. Most of the proximal plates have three spines, two larger of nearly equal size, and an adoral smaller one; other plates have two, subequal or quite unequal; distally they are pretty regularly two and subequal.

In this specimen the narrow radial paxillary area is covered with rather large spinopaxillæ, which are nearly equal on the rays, but become small and crowded on the center of the disk. The larger ones, on the proximal part of the rays, have the central spinule subconical, rather stout, blunt, mostly as long as the diameter of the paxilla; sometimes there are two; those next the margin and on the distal part of the rays have the spinule more slender; toward the tips of the rays, the spines disappear and the paxillæ are of the ordinary kind and very small. The spinules of the larger paxillæ around the central spine are long, not very slender, blunt, divergent, not all in the same plane, so that they make rather large openly stellate forms, with the slender

rays interlocking; the marginal spinules are usually ten to twelve on the larger paxillæ.

The under side of the inferomarginal plates has numerous sharp, unequal secondary spines in two rows, and between these numerous graded, rather acute, small subappressed spinules.

The secondary spines on the under side of the inferomarginal plates are of various sizes and acute; the surface spinules are small, subappressed, not very acute.

The adambulacral spines are well shown on plate xvi, fig. 2*a*, in their usual state. Sometimes there are two small spines on the adoral side of the large spine of the actinal face; sometimes the two are more unequal than in the figure.

The special feature on which this variety is based is the presence of numerous well developed spinopaxillæ on the dorsal surface.

Comparative Characters.

The most prominent features for the recognition of this species are the following:

A. The presence of two incomplete rows of short spines on the superomarginal plates, the two rows overlapping on the proximal part of the ray; and the enlargement of the first pair of plates and spines. These characters are also found in *A. antillensis* and *A. braziliensis.*

B. The decided projection of the outer ends of the inferior marginal plates, along the sides of rays, beyond the outline of the upper plates, thus forming a sort of shelf, with a lateral fasciolated lane above it. This character was even mentioned by Gray (1840).

C. The large size of one of the adambulacral spines of the second series, but less so than in *A. articulatus.* Other characters of these spines, quite as important, need more careful scrutiny.

D. The large size and flattened or lanceolate form of the inferomarginal spines, which stand two or three on a plate, the proximal one larger; and the very spinulose condition of the under side of these plates.

According to the description of Müller and Troschel, their type of *A. valenciennii* had three ranges of adambulacral spines;

the most interior contained three slender spines; the second consisted of one large compressed spine and a small one adorally placed; the external range contained three small truncated spines equal to the smaller one of the second range. It seems to be the typical form of *duplicatus.*

The young: Two very young specimens, taken by the Albatross, off West Florida, in 28 fathoms, are of interest. The smaller has the radii 3^{mm} and 8^{mm}; the other 4^{mm} and 12.5^{mm} with 12 marginal plates in each series.

The latter has already developed the most obvious specific characters, so that one would not hesitate as to its identification. The first pair of interradial superomarginal plates are already enlarged and each bears an upright conical spine as long as the radial breadth of the plate. Enlarged granules are present on some of the following plates in the places where additional spines would have appeared.

The inferomarginal spines already have their flattened linear-lanceolate form, though small. There is a prominent conical elevation in the middle of the disk of both, covered by minute paxillæ, and terminated by a very small apical pore.

The adambulacral spines and jaw-spines are like those of larger specimens, but in miniature.

The smaller specimen has ten marginal plates. No superomarginal spines have developed, but clusters of coarser granules on the first interradial plates show where they were about to form. The inferomarginal spines are more slender, but yet are somewhat flattened. The podia are relatively very large, flattened, acute.

This species is common and widely distributed in shallow water all through the West Indies, and in the Gulf of Mexico, and north to Florida.

Gray's type was from St. Vincent; that of Müller and Troschel was from Vera Cruz; those of Lütken were from St. Thomas, S. Cruz, and Florida. Perrier records it from North Carolina, but that needs confirmation. I have never seen it from so far north. In the Yale Museum there are specimens from the Florida Keys (No. 259) and also from the west coast of Florida, at Egmont Key, near Tampa Bay (E. Jewett coll., No. 1768). The Albatross dredged it off West Florida, N. lat. 26° 18′ 30″ and N.

lat. 28° 47′ 30″ in 24 and 27 fathoms. Jamaica (Clark); Dominica I. (coll. A. H. Verrill).

ASTROPECTEN ANTILLENSIS Lütken.

Astropecten antillensis Lütken, Vidensk. Meddelels., 1859, p. 47. Verrill, op. cit., p. 343, 1867. Perrier, Revision, op. cit., p. 282, 1876 (description.)

According to Lütken's original diagnosis his types had the following characters:

Dorsal marginal spines biserial in the adult; the inner series varies in number, largest near the proximal angle of the ray. Inferomarginal spines two, slender; the ventral side of these plates is covered with slender spines. Adambulacral spines six-biseriate, median ones larger; outer median one flattened. His specimens varied from 22^{mm} to 115^{mm} in diameter.

Perrier states that the inferomarginal plates are sparsely covered with small, scale-like spinules, and also have a row, transverse to the ray, of larger secondary spines. The adambulacral plates bear two rows of spines, about five in each, the middle spine in each being somewhat larger.

It is very closely allied to *A. duplicatus*, and may prove to be only a local variety of that variable species. To determine this needs a larger series than I have seen. It is also closely related to *A. braziliensis*, but apparently less so than to *A. duplicatus.*

From the latter it differs in having more slender and not so flat marginal spines; more slender secondary spines and spinules on the inferomarginals, and in the more slender adambulacral spines, which appear to be more numerous, more slender, and arranged in two rows; the larger spine of the second row is not so much enlarged as in the related species.

According to Perrier, this species becomes 120^{mm} in diameter. In his larger example all the superomarginal plates have one spine; on the first two plates it is on the upper margin; on those further out it is placed nearer the outer margin; some proximal plates have a second small or rudimentary spine on the inner margin, in line with those on the two interradial plates, thus showing a tendency to form two rows.

Perrier, from an examination of the types, considered *A. braziliensis* distinct from this. He states that the latter differs in

having only thirty marginal plates while *braziliensis* has fifty, of which those on the basal half of the ray bear two spines, but these are shorter and less acute; the former has, on the rays, paxillæ with a small central spinule and six marginal ones, increasing to eight on the disk, without change in character, while on *A. braziliensis* the radial paxillæ have eight to twelve marginal paxillæ and often two or three central ones, and on the disk they become crowded and granule-like, placed in concentric circles, losing their stellate character, and forming groups of twenty or more. Other differences are found in the adambulacral armature.

In *antillensis* there are two rows of adambulacral spines each with five or six, nearly equal, except the central one, which is a little larger, while in *braziliensis* there is an inner row with the middle one compressed, curved, and a little larger, and just behind this is one large, aboral, conical, pointed spine, having alongside of it, adorally, two others, not more than half as large; and still further back some irregularly placed small spinules (usually three or four).

He states that the inferomarginal plates are covered in both species with scales (flattened spinules), but in *braziliensis* they are more numerous, forming a uniform covering, but they are only appressed, not imbricated. In *antillensis* these spinules are more sparse and scattered.

St. Thomas (Lütken). Guadeloupe (Perrier).

ASTROPECTEN BRAZILIENSIS Müll. and Trosch.

Astropecten braziliensis Müll. and Trosch. Syst. Ast., p. 68, 1842. Duj. et Hupé, op. cit., p. 415, 1862. Verrill, op. cit., 1864, p. 343. Perrier, Revision, op. cit., pp. 284, 288, 1876. R. Rathbun, op. cit., p. 150, 1879. Sladen, op. cit., 1889, pp. 194-198 (no description).

A large characteristic specimen, from Rio de Janeiro (Coll. C. F. Hartt, No. 5,204, Yale Mus.), has long, regularly tapered, acute rays, with a narrow angulated border of marginal plates, bearing proximally two rows of acute spines, the first on each side decidedly longer and larger, marginal spines, of the lower series, are long and acute, only one large one on a plate.

The radii are 16^{mm} and 96^{mm}, ratio, 1:6; breadth of ray at base, minus spines, 17^{mm}, of paxillar area, at second pair of

plates, 12^{mm}; radius of disk equals the length of first nine marginal plates; number of superomarginal plates is 48-50, on a side.

The superomarginal plates proximally are high, angular, short and narrow, about as long as wide above, and encroaching but little on the paxillar area, so that the border of plates is narrow. Distally these plates become relatively wider, and more rounded, with the sutures oblique. The outer lateral faces of the proximal plates are nearly vertical. The first three or four plates are much compressed and short.

The inner row of dorsal spines continues only to about the ninth or tenth plate, decreasing rapidly in length to the last, which is a mere tubercle; the first is a stout, terete, acute spine, about 3^{mm} high.

The outer row of spines usually begins on the third or fourth plate and extends nearly to the tip of the rays. These are small, conical, acute, gradually decreasing from the proximal to the distal ones. The upper surface of the plates is covered with elongated spaced granules, or granule-like spinules, largest around the bases of the spines. On the outer surface they become much smaller, like fine short spinules, and grade into the longer and more slender fasciolar spinules in the sutural grooves, which are wide and deep.

The inferomarginal plates scarcely project laterally beyond the upper ones, with subtruncate ends. They have only one large marginal spine, which is rather long, somewhat flattened, tapered or acuminate, and usually very acute. The longer ones are 3^{mm} long, or equal to the length of three adjacent dorsal plates. Proximally many of the plates have no secondary marginal spine; others have, on the adoral side, a small acute spine not more than a fourth or a third as large. Distally the adoral spine becomes relatively larger and more

On the ventral side these plates have a transverse row of smaller acute spines along each margin, usually five or six in each, the outer one largest, just at the bases of the marginal spines. Elsewhere the surface is covered with small, semierect, flat, blunt or truncate spinules, not closely appressed, but semierect.

The adambulacral plates have furrow-series of three long,

rather slender spines, slightly flattened; the central one longer and somewhat compressed. The second series consists of a very large and stout, tapered, obtusely pointed aboral spine, with one or two much smaller, slender, spatulate ones on the adoral side; when there are two, one stands behind the other. They are scarcely half as long as the large one. The outer row is pretty regular and formed by three to five small spatulate spines.

The dorsal paxillar area is rather wide, nearly even, densely covered with small coronate paxillæ whose outlines are mostly easily visible. On the rays the paxillæ form irregular transverse rows, except along the median band, where they are larger and crowded. The smaller ones on the rays have eight to ten marginal spinules around one or two granule-like, larger central ones.

The larger ones may have twelve to sixteen marginal spinules and three to six in the middle. On the disk most of the paxillæ are larger; they may have sixteen to twenty-four small marginal spinules surrounding a central rosette of slightly larger capitate ones, consisting of six to nine, in a circle, surrounding one or two in the center. The spinules are all short and capitate or clavate.

The madreporic plate is large and plainly visible, surrounded by a circle of the larger regular paxillæ, with only one row of them separating it from the marginal plate.

The ocular plate is unusually small and narrow, bilobed by a deep median groove. According to Perrier (op. cit., 1876, p. 284) the dorsal radial paxillæ have eight to twelve marginal stellate spinules with two or three central ones, but on the disk the spinules become more numerous and crowded, about twenty on a plate arranged in circles, and so reduced in length as to appear like granules, showing only their hemispherical ends, due to the crowding.

The superomarginal plates bear two rather short spines on the proximal half at least. These spines may be 1^{mm} high.

The inferomarginals are almost entirely covered beneath with small flattened or scale-like, appressed spinules, which are not imbricated; near the transverse sutures these scale like spinules give place to four or five elongated, flattened, acute spines, increasing toward the upper margin, near which there is between

the two rows a long flat acute spine nearly as long as the breadth of the plate, so that this margin seems to bear three spines, instead of the two marginals found in *A. antillensis.*

The adambulacral plates have an inner marginal series of three spines, in which the median is larger than the others, recurved, and flattened; on the actinal side there is a median, large, conical, acute spine, and two others, at one side, about half as long; exterior to these are other small spines, in a row or irregularly placed.

Off Bahia, Brazil, 7 to 20 fathoms, and at Fernando Noronha (Sladen). Bay of Rio de Janeiro, common, (C. F. Hartt; R. Rathbun).

Sladen (1859) in his analytical table, puts this down as having three inferomarginal spines. This appears to be due to the presence of two secondary spines, belonging to the two central rows, standing one on each side, and a little below, the single large marginal spine. When the second true marginal spine, of smaller size, appears it is on the same level or a little above the large spine and on the adoral edge of the plate.

This is the only species from the West Atlantic, known to me, that has, normally or commonly, only one true inferomarginal spine. This is, therefore, a good diagnostic character. Various foreign species have a single spine, normally.

Another good diagnostic character is the openly subspinulose covering of the superomarginal plates, while all the otherwise similar species have them closely granulated.

Astropecten comptus Verrill, sp. nov.

Plate xii; figures 3-3*c*. Details. Type. Plate xxii; figure 1. Type.

Rays rather stout, elongated; the largest adult has about 48 to 50 spineless, evenly granulated, transversely rectangular superomarginal plates, proximally about one-third as wide as the width of paxillar area of the ray, and encroaching on the upper side so as to form a conspicuous and somewhat raised border.

Radii of the largest specimen, 18^{mm} and 95^{mm}; ratio, 1:5.3; breadth of ray at base, minus spines, 19^{mm}; breadth of paxillar area, 11^{mm} at second plate. Radii of the type specimen (No.

8,514) figured, 13^{mm} and 58^{mm}; ratio, 1:5.2; marginal plates 38.

The superomarginal plates are broadly and evenly rounded, transversely rectangular, with the sutures straight and transverse to the ray, narrow, closely fasciolated. They are closely covered with short even granules, often polygonal, due to crowding; they grade regular into the minute, short fasciolar spinules.

The dorsal paxillar area has a nearly even surface, slightly areolated by the outlines of the small paxillæ. The latter are coronate, much crowded, not forming obvious transverse rows on the rays; they have a central rosette, of about five or six short capitate spinules or granules, surrounding one in the middle, and a marginal series of numerous small ones. The median radial paxillæ are as large as the lateral ones; those of the disk rather larger, with more spinules in the central rosette.

The inferomarginal plates scarcely project laterally beyond the upper ones; they have two moderately large and long, somewhat flattened and curved, acute marginal spines. The larger proximal ones are about as long as two marginal plates. The under side of these plates is covered with minute slender, suberect spinules and has a transverse row of small, acute spines near each margin, four to six in each, the aboral ones the larger.

The adambulacral plates have an inner series of three rather long flattened spines, the median one a little longer and vertically compressed; the median series has two, or sometimes three, subequal, flattened, subspatulate or truncate spines, the aboral one slightly longer and larger; exterior to these are commonly two rows, with three each, of smaller, flat, truncated spinules, but these, on some plates, often form a divergent group of five or six around a central spine. No pedicellariæ were found on the type specimens. The largest specimen (No. 18,346, Nat. Mus.) is from off W. Florida, in 26 fathoms. No. 8,514 is from Albatross station 2,286, off Cape Hatteras, in 11 fathoms.

ASTROPECTEN RICHARDI Per.

Astropecten richardi Perrier, Revision, op. cit., p. 292, 1876.

Radii of the type 18^{mm} and 73^{mm}; ratio, 1:4. Rays slightly constricted at the base. Superomarginal plates are 22 to 25 on each side of each ray.

The superomarginals are rectangular, nearly twice as broad

as long, slightly convex, separated by a groove, spineless, and covered nearly uniformly and closely with small hemispherical granules, becoming spinuliform in the sutural grooves.

Dorsal paxillæ are pretty fine, close, and form transverse series laterally, but are irregular on the median third of the ray and on the disk. Those of the rays have three or four central granules, or short spinules, and eight to ten marginal ones. On the disk the paxilliform marginal spinules are much more numerous and finer than the central ones, which may be ten to twelve, so that their outlines are well defined by this inequality.

The inferomarginals have two large upper spines, up to 4^{mm} long, cylindric or flattened, not tapered, with a smaller spine at their bases. Their sutural grooves are bordered with regular spinules, near which is a regular row of six or seven spaced, elongated, slender, pointed spinules, arising from small notches in the plate. The spines are longer distally. There are also similar spinules on the free border and on the border next the adambulacrals. (Condensed from Perrier.)

The adambulacral plates have an inner marginal row of three divergent spines, the middle one longest; the actinal surface has two larger spines, one behind the other, the outer one often smaller or replaced by several spinules.

The type was from Cayenne, French Guiana. This appears to be very closely allied to *A. articulatus*, var. *dubius*. I have not seen the type.

Astropecten cingulatus Sladen.

Astropecten cingulatus Sladen, Voy. Challenger, Zoölogy, vol. xxx, p. 218; pl. xxxv, figs. 5, 6; pl. xxxix, figs. 1-3 (enlarged, details), 1889.

The rays are unusually short, with about 19 broad marginal plates, wider than high. The type had the radii 9^{mm} and 28^{mm}; ratio, 1:3.1.

The superomarginal plates are large and broad, at middle of ray wider than the narrow paxillar area. They therefore form a wide border to the rays; surface closely granulose.

The inferomarginal plates have two short, nearly terete, slender acute equal spines, with smaller acute spines at their bases and an aboral series of small acute spines beneath. The under side is covered with small, short, appressed spinules.

Adambulacral plates triseriate; inner row of three slender unequal; second series of two or three, short, truncate, subequal. (Condensed, from Sladen.)

Easily distinguished by the broad marginal plates and small acute lateral spines. Taken by the Challenger, off Pernambuco, Brazil, between 32 and 400 fathoms (special station record lost).

ASTROPECTEN NITIDUS Verrill, sp. nov.

Plate xx; figure 2. Type.

Regularly stellate with rather short acute rays and a prominent and wide border of spineless granulated plates.

Radii of the largest specimen (No. 18,344) are 11^{mm} and 41^{mm}; ratio, 1:3.7; breadth of rays at base, minus spines, 12^{mm}; breadth of paxillar area, at second plate, 5^{mm}. The radius of the disk is equal to the length of seven proximal dorsal plates.

The superomarginal plates are wide, evenly convex, with deep, directly transverse, sutural grooves. The first plate is enlarged above, wedge-shaped, and larger than the next. The proximal plates are rectangular, the width of the third plate is equal to three times its length; distally they become nearly square. They are closely covered with small, short, rounded or polygonal granules.

The dorsal paxillar area is narrow, less than twice the width of the adjacent marginal plate at the base of the rays. The paxillæ are not very small and form pretty obvious transverse rows on the rays; those along the middle band are as large as the others. Their spinules are regularly stellate, small, clavate, about 10 to 15 on the larger ones, around the margin, surround one or two central spinules of the same size. Those on the disk are similar in size, except at a very small raised central area, where they become very small and crowded. The madreporic plate is partly visible, small, convex, separated from the marginal plates by about three rows of paxillæ.

The ocular plate is small, broader than long, deeply bilobed, strongly upturned.

The inferomarginal plates do not project beyond the upper ones; they bear two moderately long, tapered, acute, subequal spines. Their under side is covered with fine, acute, suberect spinules and two transverse rows of small acute spines.

The adambulacral plates have three slender spines in the inner row, the middle one longer, larger, and compressed; sometimes there are four or five spines proximally, on a few plates. The second row usually has about three smaller and more slender subequal spines; the third row has three to five still smaller ones; a fourth row of three small spinules is sometimes present. Sometimes the spinules of the outer part form a divergent group of eight or nine.

A papillose pedicellaria often replaces the spines of the second series on more or less of the plates in variety *forcipatus.*

Young specimens, with the greater radius 13^{mm} to 16^{mm} have essentially the same characters.

Dredged by the Albatross off West Florida, at station 2,318, in 45 fathoms; station 2,836, in 111 fathoms; station 2,406, in 26 fathoms; and off Georgia, station 2,417, in 95 fathoms (variety); station 2,418, in 95 fathoms; station 2,313, in 99 fathoms (variety). The largest specimen (described above) is from station 2,762. (No. 18,344.) Range in depth, 20 to 111 fathoms.

ASTROPECTEN NITIDUS var. FORCIPATUS, nov.

Plate xvi; figure 3. Details. Plate xx; figure 1. Type.

This form agrees with the preceding in size, shape, and nearly all other respects, except the armature of the adambulacral plates.

In this a large, blunt, conical pedicellaria, with three to five slender valves, replaces all or most of the spines of the second series. It it usually near the aboral edge of the plate, and in that case there may be one or two small spines on the adoral edge. But it is frequently on the middle of the plate with no spine alongside. Two may occur on one plate, side by side.

These pedicellariæ may occur on nearly every plate, or they may be absent on part of them. The four or five slender outer spines are usually present with the pedicellaria.

Similar pedicellariæ occur on the few interactinal plates and sometimes a few of smaller size are on the inferomarginal plates.

Taken off South Carolina and Georgia by the Albatross, in 95 and 99 fathoms (Nos. 10,067 and 10,543); and off W. Florida, in 26 fathoms.

ASTROPECTEN ALLIGATOR Perrier.

Astropecten alligator Perrier, op. cit., 1881*b*, p. 30; Etoiles de Mer, p. 270, 1884.

According to Perrier the essential characters of the type are as follows:

Radii 9^{mm} and 40^{mm}; ratio, 1:4.5; breadth of ray at base, 9^{mm}. Superomarginal plates are thirty on each side of a ray.

The disk and rays are flat; rays acute. The inferomarginal plates project laterally beyond the upper ones.

The superomarginal plates are little elevated, almost square; interradial ones broader than long. They are covered with pretty coarse, prominent, spaced granules. Three or four proximal plates bear each a single, pretty short, conical spine, on the middle of the interior border; that on the triangular first plate is largest; those farther out become nearer to the exterior side.

The inferomarginal plates have two flat and acute marginal spines; underneath they have a row of about three smaller flat spines along the aboral margin; the rest of the surface is covered with acute scale-like spinules, among which are some larger obtuse, flat spinules.

The adambulacral plates have a furrow-series of three divergent spines; one or two smaller ones are placed on the lateral margins, and three on its exterior margin. Sometimes there is also a central spine on the plate.

The paxillar area, at the base of the rays, is about equal to four times the breadth of the marginals. The paxillæ are small; they have six to eight slightly clavate spinules surrounding a group of central ones. They form pretty evident transverse rows of about fifteen, proximally, on the rays. Off Alligator Key, Florida, in 147 fathoms.[26] I have not studied the type.

ASTROPECTEN NUTTINGI Verrill, sp. nov.

Plate xii; figures 2-2*e*. Details. Plate xxi; figures 1-2. Type.

A regularly stellate species, rather thin vertically. The disk is usually rather flat, and often has a central conical elevation.

[26] Perrier (1884) gave the depth as 147 feet. There is no such depth given in the original lists of dredgings off Alligator Reef, but there is one of *147 fathoms* (No. 194 P). Probably there was an error in transcribing the label.

Radii of one of the larger are 10^{mm} and 44^{mm}; ratio, 1:4.4. Another has them 10^{mm} and 38^{mm}; ratio, 1:3.8. Another, 8^{mm} and 32^{mm}; ratio, 1:4. The margin is narrow and not very thick, owing to the smallness of the marginal plates. The dorsal paxillar area is relatively wide.

The paxillæ are small, nearly equal and even, regularly stellate, arranged in obliquely transverse rows. Two rows usually correspond to each superomarginal. In the proximal interradial region there may be ten paxillæ in a row from the margin to the median radial line; opposite the eighth pair of plates there are about six; toward the tips of the rays the rows are indistinct. The larger proximal paxillæ may have eight to ten spinules around the margin and one, or less often two, in the center. At about the middle of the rays the larger ones have six to eight marginal and a single small central one. The spinules are slender, not very long, obtuse, or slightly capitate, all nearly equal. The paxillar columns are rather high and slender, with round or elliptical convex tops. They are in close contact by their bases along the median line, but elsewhere have isolated papular pores between them.

The superomarginal plates are rather small, higher than long, proximally, with the outer side nearly vertical and the upper end narrow but prominent. Their sutures are deep and finely fascioled. There are about thirty-two plates on each side of a ray, in the larger specimens.

The superomarginal plates are regularly covered with small, short and very slender spaced spinules, usually as fine and sometimes finer than those of the dorsal paxillæ; those in the lateral fascioles are still finer and very numerous. Each plate usually bears a small, rather short, tapered, acute spine on the most convex part of the upper side; these are larger proximally, gradually decreasing distally, and becoming very small on disappearing toward the tips of the rays. They are usually in a very regular row, but some are often lacking and sometimes there is a smaller one (sometimes two) close beside the larger one.

The inferomarginal plates correspond in number and length with the upper ones Their fascioled suture are deep and somewhat oblique proximally, becoming decidedly oblique distally. These plates are prolonged to the adambulacrals and are but little

convex. Their outer surface is well covered with small, unequal, acute spines, which form about three or four irregular rows, transverse to the rays. These spines, at the middle of the row, may be as long as the radial breadth of the plate. There may be six to eight or more in a row. The upper ones, two or three in number, are larger and longer and stand at the base of the two large spines that stand on the superior margin of the plate, side by side. These are a little curved, often somewhat flattened, tapered and acute, those on about the eighth to tenth plates are somewhat the larger. In length they about equal the radial breadth of two plates, and are more than twice as long as the longest upper marginal spines.

Interactinal plates are very small and few, in the interradial areas. They are spinulated and some of them usually bear papilliform pedicellariæ.

The adambulacral plates proximally have a marginal row of three slender acute spines, of which the median is a little the longest and largest, and occupies the apex of the angular margin; it is a little curved and usually compressed. On the actinal surface of the larger subproximal plates, there are usually four or five similar, slender spines (three or four more distally). These may stand nearly in two rows, but normally three or four stand on the border of the plate and one, slightly larger, stands nearer the center, so that, as preserved, they often form a substellate group; but more often they appear irregular and crossed, due to contraction or pressure. Sometimes four or more of these spinules converge and form a fasciculate pedicellaria, especially on the jaws, but these are often absent or very few.

The madreporic plates is small and nearly concealed by the paxillæ. A minute dorsal pore appears to be present at the summit of the central cone.

It was taken by the Bahama Expedition at station 64, off American Shoal, Fla., in 110 fathoms (five specimens, including the type); stations 56, 57, 58, Pourtales Plateau, in 200 to 225 fathoms (several, one specimen is rather thicker and more spinose than the type.) Station 28, off Florida, 116 fathoms, one young. It was taken by the Albatross, at station 2,418, in 90 fathoms, off Georgia, N. lat. 33° 20′ (No. 18,350).

This species appears to be closely allied to *A. alligator* Per-

rier. The description of the latter is not sufficiently precise, and in respect to the adambulacral spines, it is somewhat ambiguous. The description, so far as it goes, would indicate that it is a distinct species, but a reëxamination of the type is necessary in order to determine this with certainty.

Astropecten americanus Verrill.

Archaster americanus Verrill, Amer. Journ. Sci., vol. xx, p. 402, 1880; Expl. by Albatross in 1883, p. 542, 1885.
Astropecten americanus Verrill, Proc. Nat. Mus., vol. xvii, p. 255, 1894; Distribution New Eng. Echinod., p. 133, 1895.

Plate xvi; figures 1-1*a*

The body is decidedly flat and thinner than in most species. Rays long, slender, tapering to rather acute tips.

The type had the radii 12^{mm} and 74^{mm}; ratio, 1:6.16. It becomes considerably larger than this, with the larger radius up to 85^{mm} or more. Ratios vary from 1:5.25 to 1:6.25. The radius of the disk is equal to the length of the first eight marginal plates.

Among several thousands, a few were found with six and some with four regular rays.

The dorsal paxillary area is rather wide; at the base of the rays it is about four times as wide as the opposite plate. The paxillæ are small, with a slender elevated column, and a divergent group of six to ten or more very slender elongated spinules, surrounding one or two central ones of similar size and form. They form narrow transverse rows on the rays. The rows are openly spaced so that the rather large and numerous papular pores can usually be seen. There is a narrow median band destitute of papulæ, where the paxillæ do not stand in rows.

The superomarginal plates are relatively small and numerous (40 to 50 or more), becoming very small toward the acute tips of the rays. At the base of the rays their width is about one-fourth that of the paxillar area. They are rectangular proximally, broader than long, with nearly straight, deep and wide, transverse, densely fasciolated grooves; distally they become nearly square, with slightly oblique sutures. Proximally the outer and upper surface is usually transversely flat or distinctly concave, owing to the presence of a thickened margin next the

sutures. They do not rise much above the paxillar area, nor encroach much upon it, but yet form a regular raised border.

Their outer surfaces are covered with very small, acute, spaced spinules; at the sutures these change rather abruptly into the longer closely fasciolated spinules. Nearly always there are no traces of spines or tubercles on these plates, but very rarely a small conical spine occurs on one to three of the proximal plates, but with no regularity nor constancy.

The inferomarginal plates project laterally a little beyond the upper ones; their lower side is flattened, and usually a little thickened at the aboral margin. They bear two slender, elongated, slightly flattened and very acute marginal spines; just above the base of each there is sometimes a small papilliform pedicellaria. The under side is covered with suberect, very acute, small, spaced spinules and small spines of various sizes; the larger ones form an aboral submarginal row, but others occur irregularly.

Interactinal plates are few and small, next the jaws; they are spinulose and often have a central pedicellaria.

The adambulacral plates have a furrow-series, usually of three slender spines distally, but often with four or five proximally. The second and third rows, when there is no pedicellaria, usually consist each of three or four slender, nearly equal spines, the outer ones a little smaller.

Often there is a large papilliform pedicellaria, usually with three valves, which replaces all or most of the spinules of the second row; if any remain they are on the adoral side.

The valves of the pedicellariæ are usually strongly spatulate, incurved somewhat, and truncate or notched at the tip. Although most have three valves, some have four, and others have but two.

The madreporic plate is large, with deep gyri. It is usually wholly or partly exposed and separated from the marginal plates by only one or two rows of paxillæ.

The ocular plate is small, about as wide as long, deeply bilobed, and with a proximal notch.

The jaw-plates are narrow and much elevated, densely covered with small slender epioral spines, the two clusters convergent. Adoral spines similar and very numerous. Peroral spines numerous, some much thicker ones at the apex are obtuse.

Color in life, bright light yellow to orange-yellow; sometimes pale yellow.

This species was taken in vast numbers (many thousands), at about a hundred stations, by the Fishhawk and Albatross, 1880 to 1887, during the Explorations by the U. S. Fish Commission, off the eastern coast of the United States, in 43 to 296 fathoms.

It was most abundant in 60 to 150 fathoms, where two thousand to five thousand were repeatedly taken by us in a single haul of the trawl.

It occurs abundantly from N. lat. 40° 23′ to the region off the Carolina coasts. Farther south it seems to be less common, but it reaches the Florida Straits, West Florida, and the Caribbean Sea, off Colombia.

It was taken by the Albatross at station 2647, in 85 fathoms, in the Straits of Florida; at station 2399, in 196 fathoms, off West Florida. Also at station 2143, in the Caribbean Sea, north of Colombia, in 155 fathoms (variety *subgracilis*).

This is probably the most abundant starfish, off our coast, if we except the littoral species of *Asterias*.

Variety SUBGRACILIS, nov.

Rays flat, long, narrow, very slender distally and acute. Paxillar area rather narrow, paxillæ small, with about eight to twelve very slender elongated divergent spinules, which in the dry specimens are mostly grouped in a fasciculate bundle, leaving the papular pores exposed. Distally toward the tips of the rays the paxillæ become very small with almost microscopic spinules. Proximally they form spaced transverse rows, except along the median band where there are no papulæ. Some of them have a small papilliform pedicellaria replacing part of the spinules.

Madreporic plate rather large, convex, exposed. Ocular plate smaller and narrower than in the typical form.

Superomarginal plates nearly as in the ordinary form, but with fewer and more minute spinules.

Inferomarginal spines are normally two, usually unequal, the adoral smaller and sometimes absent. These spines are very slender and acute. Small pedicellariæ often occur just above their base, and also on the under side of the plate.

Adambulacral spines are all slender; inner series of three, elongated and tapered; second series of two, subequal, slender, as

long as inner ones, but usually replaced by a large three-valved to five-valved pedicellaria, with spatulate valves. These often form a regular and continuous series.

This variety differs from the typical form mainly by having a smaller disk and more slender rays, and more slender spines and spinules, and its adambulacral pedicellariæ are larger and more fully developed than in the type-form.

Taken in the Caribbean Sea, off the northern coast of Colombia, in 155 fathoms. Albatross station 2143, No. 18,464.

ASTROPECTEN CILIATUS Grube.

Astropecten ciliatus Grube, Archiv. fur Naturgeschichte, vol. xxiii, p. 340, 1857.

According to the brief diagnosis of Grube, this species belongs to the group of species which have a cluster of six to eight or more spines on the actinal face of the adambulacral plates. He mentioned no superomarginal spines. These points would make it seem related to *A. americanus* and *A. nitidus*, but otherwise it does not appear to agree with either of those species.

The type was 4.5 inches (about 108^{mm}) in diameter; ratios of the radii, 1:4.5; superomarginal plates, 45; inferomarginals, 42.

The superomarginal plates are evenly granulated. The inferomarginals have two large, equal, flattened spines with three shorter ones below them.

The adambulacral plates have three furrow-spines and about eight on the actinal face, of which one is longer.

Puerto Cabello, Venezuela.

Doubtful species of ASTROPECTEN.

Astropecten spatuliger Perrier.

Revision, p. 296, 1876.

Said to be from Nicaragua, but whether Atlantic or Pacific is not stated. It is much like some Pacific coast species, with broad rays and flat spines.

Genus BLAKIASTER Perrier.

Blakiaster Perrier, op. cit., 1881, p. 28; op. cit., p. 265, 1884; op. cit., p. 242, 1894. Type, *B. conicus* Per. Verrill, Revision Genera, p. 218, 1899. Fisher, The Genus Blakiaster, Bull. Mus. Comp. Zoöl., vol. liv, No. 4, p. 161, pl. 1, 1911; also, op. cit., 1911*b*, p. 40. Verrill, op. cit., 1914*a*, p. 322.

The dorsal plates are rounded, decidedly convex above, with about six basal lobes, which unite by overlapping, leaving about six simple papular pores around each plate, except on the disk, along the median row, and on a small interradial area, where papulæ are lacking and the plates are more closely joined.

The dorsal plates are protopaxillæ, bearing many small, short, divergent spinules on the convex portion, but not forming fascioles. On the disk and base of the rays there are a few small interpolated plates.

A single row of plates separates the superomarginals distally in the type. There are no well-marked fascioles between the superomarginal plates. The marginal plates are thick, convex, regularly paired, somewhat oblique distally. The superomarginals are granulated or minutely spinulated. The inferomarginals are spinulated and also, in the type, bear a few larger spines in a submarginal transverse row. Grooves between the plates are shallow and have only poorly developed fascioles.

The interactinal plates form series subparallel to the adambulacrals, but there are a few unpaired plates in the median interradial line. The interactinal plates are tesselated, somewhat convex, roundish or subpolygonal, and bear divergent spinules that do not form evident fascioles nor regular radial rows.

The adambulacral plates are somewhat oblique, with an angular inner end, which bears a row of four to six spines; the actinal surface is covered with small divergent spinules, not fasciolated.

Jaws stout and convex, covered on the actinal side with spinelets, and with a row of about nine longer spines on each side. The peroral spines, in a pair, are larger.

The pedicellariæ are small, papilliform, with three to six valves surrounding a small pit in the plate. They are often lacking. Superambulacral plates are present. A small dorsal pore was present in some of the specimens examined by me.

Professor Fisher has given (op. cit., 1911) a more detailed description of the type of this genus, with photographic figures. I have also studied the type, as well as several other specimens. No other species is known, unless *Bunodaster ritteri* Ver., of California, be considered congeneric, as Fisher suggested (1911*b*, p. 40).

Bunodaster differs from *Blakiaster* by its less massive and differently shaped marginal plates, which are less complex and

have more fully developed fascioles. The lower marginals have the spines in a central row or group, not submarginal. There is no differentiated median radial series of dorsal plates; nor any notable number of secondary ossicles, so evident in *Blakiaster*; nor any median radial area destitute of papulæ, as in the latter. There are well defined fascioles between the adambulacral and interactinal plates, not found in the latter; and the adambulacral spines of the adoral plates are deeply sunken in the groove, as in *Persephonaster*, but not in *Blakiaster*. The abactinal plates are thinner, more regularly stellate, and more delicately articulated by the slender radial lobes than in the latter, so that the test is more flexible. No pedicellariæ were found in the type of *Bunodaster*.

In some of these characters *Bunodaster* is near to *Persephonaster*, but the latter lacks the odd interactinal plates, found in *Blakiaster* and in *Leptychaster*.

From the latter *Bunodaster* differs in the characters of the dorsal plates; in the less profoundly fasciolated grooves between the marginal plates; and in other characters; but it is perhaps as nearly allied to the latter as to *Blakiaster*. The genus *Bunodaster* is certainly closely allied to *Blakiaster, Persephonaster*, and *Leptychaster*, especially to the two former.

Perrier, in his later report (1894), has united *Blakiaster* with *Leptychaster*, but it seems to me sufficiently distinct. In this genus the interactinal plates are not arranged in definite radial series, nor do they have well developed fascioles between them. On the contrary, they have a rather irregular, crowded, tesselated arrangement, the plates being roundish or polygonal, pretty closely united, without the deep, sutural, fasciolated furrows found in *Leptychaster*. The marginal plates, also, have only rudimentary fascioles. The jaws are stout and evenly convex, instead of thin and carinate. The dorsal plates are larger, rounded, more convex, more regular, and less paxilliform. *Leptychaster* does not have spines on the inferomarginal plates.

BLAKIASTER CONICUS Perrier.

Blakiaster conicus Per., 1881, p. 28; Etoiles de Mer, p. 265, pl. ix, fig. 2, 1884. Verrill, Trans. Conn. Acad. Sci., vol. x, p. 218, pl. xxvii, fig. 7, 1899.

Leptoptychaster conicus Per., Exp. Trav. et Talism., p. 243, 1894.

Blakiaster conicus Fisher, op. cit., 1911, p. 161, pl. i; op. cit. 1911*b*, p. 40, note. Verrill, op. cit., 1914*a*, pp. 322, 371.

Plate iii; figure 4. Plate xi; figure 5. Details. Plate xiii; figures 1-1*c*. Details.

The type of this species, in the Museum of Comp. Zoölogy, is small and doubtless quite young. Some specimens obtained later are rather larger, but none appear to be adult.

Radii of the type 10^{mm} and 27^{mm}; ratio, 1:2.7; marginal plates fifteen on each ray.

The median radial row of dorsal plates is slightly differentiated, the plates having more hexagonal bases, with shorter lobes, and therefore more closely united; they have no papular pores between them; near the base of the rays they have a few smaller plates between them, and such secondary plates also occur on the disk.

The spinules of the dorsal plates are slender, rough, divergent, but not fasciolated; the central spinules are longer and stouter than the others.

The superomarginal plates are closely covered above with short or granule-like spinules, which grade into slender spinules laterally, forming rudimentary fascioles, and become longer on the lower side.

The inferomarginals are more convex or swollen; they are covered with small sharp spinules, and also bear an oblique row of two to four or more slender, acute spines, situated near the distal margin, and usually appressed, so as to be directed distally.

The proximal interactinal plates are roundish or subpolygonal, rather crowded, tesselated or overlapping by their edges, with no evident fascioles between them. They are covered with slender, acute, divergent spinules. They have about three or four divergent rows or chevrons with one unpaired plate in each row, except the first. A single row extends on the rays, beyond the disk.

The adambulacral plates are decidedly oblique, transversely elongated proximally, with the inner end angular and projecting into the groove. There are about five slender divergent spines in a row along the angular margin. The actinal surface is covered with a divergent cluster of small, slender spinules, similar to those of the interactinal plates. About ten proximal plates

correspond to the first pair of inferomarginals. The ambulacral feet are conical, subacute.

The jaw-plates are prominent, convex, but not much enlarged, covered with acute spinules, the apical ones stouter.

The adoral series of spines are not deeply depressed into the groove, as they are in some of the allied genera.

The pedicellariæ are small and papilliform or conical. The largest are on the interactinal plates. (See pl. xiii, fig. 1*c*.) They have four to six small, slender, convergent valves. Those on the dorsal and marginal plates are considerably smaller with three or four valves. They sometimes occur, also, on the adambulacral plates.

For some additional details see the description and photographic plates by Fisher (op. cit., 1911).

Perrier (op. cit., 1904) united this genus to *Leptychaster* unnecessarily.

The two original specimens were from the Blake Exped., station 25, in 92 fathoms, off Grenada; and in 175 fathoms, off Havana.

The Bahama Expedition took it at sta. 58, in about 200 fathoms, off Florida (4 specimens), and sta. 64, in 110 fathoms, off American Shoal (4 specimens).

It was dredged by the Albatross at several stations in the West Indies, in 92 to 175 fathoms, and in the Gulf of Mexico, off Alabama, in 178 fathoms, station 2357.

Genus Sideriaster Verrill.

Sideriaster Verrill, Revision Genera, p. 219, 1899. Type, *S. grandis* Ver.

Form broadly stellate with a very large disk; dorsal surface convex, and capable of inflation, closely covered with uniform, stellate paxillæ. Upper marginal plates are not large, lateral in position. Interactinal areas large, with numerous plates, mostly in single radial rows, with fasciolated grooves between.

The dorsal paxillæ are large, closely arranged, and nearly uniform in size and shape, regularly stellate, with short, even spinules.

The madreporic plate is *very large*, round, flat, fully exposed, and has very numerous, thin, radiating gyri.

Papular pores are very numerous and are arranged singly, about six around each plate over the whole of the disk and rays, even close to the ends.

There is no distinct dorsal pore visible, nor do the central plates differ in size from those of the disk in general.

Marginal plates are small and not prominent. The upper ones are entirely confined to the margin, and are granulated, without spines. The lower ones form the lower part of the margin, but extend also on the disk below; they bear spinules with a median row of larger spines.

Interradial actinal areas are large, with numerous plates, the distal ones extending to the distal third of the rays. They are arranged in single radial series, each series usually corresponding to an adambulacral plate and most of them to a marginal plate, but some of the series are short and do not reach the margin, there being more adambulacral than marginal plates proximally, but distally they generally correspond in number, though there are sometimes, locally, two marginals to one adambulacral. These plates are covered with granules, and have divergent, fasciolated spinules along their radial margins, thus forming fasciolated grooves that are coincident with those between the marginal plates.

The adambulacral plates have a prominent furrow-angle, on which there is a large, median, compressed spine; at each side of this there are, in the furrow-series, two or three erect flattened spines; a stout spine occurs on the center of the actinal side, with a single or double row of shorter flat spines back of it.

The jaws are large, not very prominent, covered with numerous short, blunt spinules, and have furrow-spinules like those of the adambulacral plates.

The only known species of this genus is from the Gulf of Mexico, in 68 fathoms.

Sideriaster grandis Verrill.

Sideriaster grandis Verrill, Revision Genera, p. 220, pl. xx, figs. 8-8*b*, 1899.

Plate xii; figures 5-5*b*. Details.

Large, regularly five-rayed, with a broad, somewhat swollen disk, regularly and broadly incurved at the sides. The rays are rather large and rapidly tapered. Greater radii, 133-138^{mm}; lesser, 40^{mm}. Ratio, 1:3.4.

The dorsal paxillæ are round and high, remarkably uniform in size, arranged on the rays in imperfect, transverse, oblique rows. They bear a round, rosette-like cluster of rather coarse, short, clavate or capitate, divergent spinules, of which one is usually central, with 6 or 7 in a circle around it, while about 15 to 18 form the marginal row, interlocking with those of the adjacent plates, so as to conceal the papular pores. The latter are rather large and regularly arranged over the whole disk and nearly to the ends of the rays, usually six around each paxilla. The bases of the paxillæ appear stellate.

The margin is formed mostly by the upper plates, which do not extend at all upon the upper side. They are small and short, those on the interradial margins shortest and highest, at least four times as high as long. They are covered with coarse, rounded granules, and bordered with fascioles of slender spinules. The lower marginals are of the same length and extend considerably on the under side. They are covered closely with small, appressed, flattened spinules, largest centrally, grading laterally to the marginal fasciolated spinules. On the middle of each plate there is a vertical row of about four stout, tapered, more or less flattened, acute spines.

The madreporic plate is remarkably large and flat or slightly concave, with very numerous and thin radiating gyri.

The interactinal plates are granulated nearly like the upper marginal plates. Other under parts have been described above under the generic description.

Pedicellariæ occur in small numbers on the adambulacral plates and on the first row of interactinals. They have two or three short, stout, flattened, spinuliform blades, similar in size to the adjacent spinules.

Dredged by the Albatross at station 2378, in N. lat. 29° 14′ 30″; W. long. 88° 09′ 30″, in 68 fathoms, in the Gulf of Mexico, off Mobile, Alabama. (No. 10877, U. S. Nat. Mus.)

Sideriaster? vestitus (Say) Verrill.

Asterias vestita Say, Journ. Philad. Acad., vol. v, p. 143, 1825.

Astropecten vestitus Lütken, op. cit., 1859, pp. 27, 54 (no description). Verrill, Proc. Boston Soc. Nat. Hist., vol. x, p. 339, 1866 (no description).

Sideriaster ? vestitus Verrill, Ann. and Mag. Nat. Hist., vol. xiv, p. 21, 1914*c*.

This has always been a doubtful species. I am not aware that

it has been redescribed by any writer since Say, in 1825. Lütken mentions it as probably an *Astropecten*, but adds nothing to its history. It is ignored by Perrier, 1876, and by nearly all later writers, except quotations by name only.

The description by Say is very incomplete. Aside from characters common to all species of *Astropecten*, the only points of importance that he gives are the following:

The disk is broad, rays depressed. The dorsal paxillæ have ten to eighteen small, equal, cylindrical spinules.

The marginal plates bear "about four very much compressed, subquadrate, truncated spines, which are vertically appressed to the surface of the plate, and imbricated with respect to each other." Diameter fourteen inches. Cape May, N. J. "It is very rare on this coast."

Presented to the Philadelphia Academy of Natural Sciences, by Mr. Robbins.

In Ives's more recent list of Asterioidea (1889), in the collection of the Academy, no such specimen is mentioned. Probably the type is lost. It is probably not an *Astropecten.*

In having a large disk, and especially in having four appressed spines in a transverse row on the inferomarginal plates, the *Sideriaster grandis* V. agrees, perhaps, with Say's species. But he gives too little, as to other characters, to enable us to say whether they are related. *Sideriaster grandis* is from the Gulf of Mexico, in 68 fathoms, off Mobile, Alabama, and therefore might, possibly, occur in deep water, off Cape May, but it is not very probable that it does, for the very numerous dredgings of the Albatross in that region brought up nothing of the kind. Nor do we know whether the four appressed spines, mentioned by Say, occupy the same places as those of *Sideriaster.* This comparison, therefore, is intended as a suggestion.

Perhaps the most notable thing said about *A. vestitus* is the remarkably large size. Say states that his unique specimen was one foot and two inches in diameter. This size is much greater than that of any American *Astropecten* seen by me or recorded by others, but is not unusual for species of *Luidia.* Some foreign species of *Astropecten* have been described of that size, however.

As Say does not mention any spines of the superomarginal

plates (as he does in the case of *A. articulatus*, where they are very small), it is to be presumed that there were none. The existence of four peculiar, appressed, flat spines, presumably on the inferomarginal plates, is the most important character given. He does not say that any are marginal.

The locality, Cape May, southern New Jersey, is north of the usual range of *A. articulatus*, and every other littoral species of the genus, known on our coast, but *A. americanus* occurs farther north, in deep water, off the coast. The latter, however, does not agree at all with the description.

It is possible that this specimen was not really obtained at Cape May, or if so, that it may have been fished up from deep water, off that shore, by local fishermen.

It is possible, though not probable, that it was only a very large specimen of a variety of *A. articulatus*, which is a very variable species, and not infrequently lacks spines on the upper marginals.

Genus Plutonaster Sladen.

Plutonaster Sladen, Narrative Challenger Exped., vol. i, p. 610, 1885; op. cit., p. 81, 1889. Perrier, Exped. Trav. et Talisman, pp. 312-313.

Form is stellate with a broad flat disk and rapidly tapered, rather rigid rays. The marginal plates are large and thick, rather rectangular, encroaching on the upper side to form a stout border, and standing opposite the lower ones.

The marginal plates of both series are closely covered with elongated granules. They may bear short, thick spines on one or both series, or spines may be entirely lacking. Grooves are fasciolated. The dorsal area is wide and closely covered with small parapaxillæ, showing no median radial row, but often in transverse rows on the rays.

Papulæ are widely distributed, except on the interradial areas. Pedicellariæ are generally absent, when present papilliform, with three or four valves. They occur on the interactinal plates. Dorsal pore distinct.

Adambulacral plates have a regular marginal row of small spines, and on the actinal face two or more longitudinal rows of mostly short or almost granule-like spinules; sometimes one is spiniform. The interactinal plates are numerous and stand in regular rows, from the adambulacral to the inferomarginal plates.

This is essentially a deep-sea genus. The species seldom occur in less than 300 fathoms, but are often abundant at greater depths. Some occur in 1,500 to 2,000 fathoms.

Plutonaster intermedius Perrier.

Goniopecten intermedius Perrier, op. cit., p. 25, 1881; op. cit., p. 251, pl. vii, figs. 1, 2, pl. iv, fig. 4, 1884.

Plutonaster intermedius Perrier, Exped. Trav. et Talisman, p. 316, 1894 (redescribed).

Perrier (1884, p. 252) mentions several very young specimens that he thinks belong to this species, as coming from 70, 103, 120, and 213 fathoms, in the Lesser Antilles. They were from 8 to 25^{mm} in diameter. Specimens so small as that, in this genus, can seldom be identified with any certainty, unless older ones come from the same locality, to form a series.

Adults of this species occurred in 833 to 955 fathoms and deeper. Therefore I doubt the identification of these young ones. The description is brief.

I did not see them when I examined the Blake collection. They are entered here, for want of a better place, until they can be studied more fully.

It should also be remembered that a large part of the Blake starfishes (as well as those of the Albatross) were taken by tangles, and that it is not an uncommon thing for small starfishes and other organisms to be overlooked and thus left on the tangles to come up again, with a subsequent haul, perhaps from a very different depth. Thus there may well be doubt of some unusual records of single small specimens of such objects. I write this from personal experience of 20 seasons in dredging.

Family Goniopectinidæ Verrill, 1899, p. 213.

Stellate with elongated rays. The marginal, adambulacral and actinal plates are bordered with peculiar pectinate spinules united by a web, thus forming specialized, continuous fascioles.

Dorsal plates are paxilliform or columnar and covered with small spinules. They are arranged in oblique transverse rows on the rays.

Marginal plates large, regularly paired, the sutures corresponding above and below; sometimes they are spinose. There may be

an odd interradial marginal plate in each series (*Prionaster*). Surface of the marginal plates usually smooth or with a few scattered granules, sometimes entirely granulated, usually covered with a thin membrane.

Interactinal plates form radial series, usually double, running from the adambulacral to the marginal plates, with deep fasciolated grooves between them, continuous with the fasciolated grooves between the marginal plates.

The adambulacral plates project over the ambulacral furrows, forming constrictions; they bear a curved or angular series of furrow spinules united by a basal web.

The jaws are rather large and very prominent, with an open suture. They bear two or more enlarged apical spines, and more or less numerous smaller spinules on the actinal side.

Genus PRIONASTER Verrill, 1899, p. 215.

This genus differs from *Goniopecten* especially in having an odd interradial marginal plate, in each row, and a double series of unpaired interactinal plates corresponding to them.

For more details see the original description. The genus includes only the following species:

PRIONASTER ELEGANS Verrill.

Prionaster elegans Verrill, Revision Genera, op. cit., p. 216, plate; figures 4, 4*a*, 4*b*, 4*c*, 1899.

Plate xii; figures 4-4*c*.

Disk small; sides high and vertical, evenly incurved; rays high and nearly square at base, tapering regularly to the slender tips.

Radii of the type, 14^{mm} and 70^{mm}; ratio, 1:5.

The marginal plates are oblong and much higher than long on the disk, but gradually become squarish on the rays. The upper and lower are exactly coincident, so that the vertical sutures are continuous. Their sides are nearly perpendicular and they encroach only a short distance on the disk, but at the middle of the rays each series is about as wide as the dorsal area; distally, near the tip of the rays, they are separated only by a single row of very small paxillæ. The distal plates bear groups of small spaced granules near the upper end. Each of the upper ones,

except on the distal third of the rays, bears a small, movable, tapered, acute spine at the upper angle; those at the base of the rays are longer than the rest.

Some of the inferomarginal plates of the rays have a similar, but smaller, spine at the lower angle and near the distal edge of the plate; most of the interradials have also a small cluster of minute granules near the lower end. All the marginal plates are bordered by a very regular and even series of small spinules webbed together to their tips. Those of the upper plates are much more numerous, finer and closer, and more evenly pectinate; they nearly touch across the grooves. Those of the lower plates stand a little apart and are more divergent, about half as many in the same space as on the upper plates, and very similar to those between the actinal plates.

The actinal areas are not large and extend to about the eighth adambulacral. The median odd series consists of two closely united rows of about six each, the distal ones becoming very small. The next series contains a row of five plates and one of three similar plates; this series corresponds to the second and third adambulacrals.

The adambulacral plates are broad and roundish, the proximal ones quite oblique; their furrow-edge projects over the furrow and bears a row of 10 to 12 small, slender, acute spinules, which are somewhat divergent and webbed together for about half their length; they meet or interlock across the furrow, leaving rounded or ovate open spaces between them for the passage of the large and tapered ambulacral feet. On the outer and lateral margins of the plates there is also a series of divergent, webbed, fasciolated spinules like those of the actinal plates.

The madreporic plate is rather large, with fine gyri. The dorsal nephridial pore is situated in the center of a low elevation composed of very small, round paxillæ.

Taken by the Albatross at station 2401, in the Gulf of Mexico, in 142 fathoms. (No. 18,428, U. S. Nat. Mus.)

For more details see the original description.

Family Luidiidæ Verrill.

Luidiidæ Verrill, Trans. Conn. Acad., x, p. 201, 1899. Fisher, op. cit., 1911*b*, p. 105. Verrill, op. cit., p. 333, 1914*a*.

Luidiinæ (subfamily) Sladen, op. cit., pp. 175, 244, 1889.

Disk small, covered with true paxillæ, which are usually largest at the sides of disk and rays; rays five to ten or more, long, flat, flexible in life. Superomarginal plates small, paxilliform, often indistinguishable from the dorsal paxillæ. Inferomarginals transversely elongated, large, spinose, fascioled, corresponding in number and radial length with the adambulacrals and separated from them throughout the rays by a row of small peractinal plates.

Pedicellariæ usually present on the actinal side, forceps-like, with two or three blades, or spiniform.

Ambulacral feet large, flattened, muscular; can be used as paddles for gliding rapidly along the bottom just under the surface of sand or mud. I have observed (1901) that *Luidia clathrata* swims or paddles with remarkable speed, just under the surface of the sand in shallow water, and that it swims or glides actively in an aquarium, by using its feet as paddles.

The dorsal nephridial glands, or "cœcal appendages," intestine and dorsal pore are lacking. The papulæ are branched.

This family is very distinct from all others, but nearest to *Astropectinidæ*. It is well represented in the West Indies, as in most tropical and subtropical seas.

Genus Luidia Forbes.

Luidia Forbes, Wern. Trans., 1839, p. 14; Mem. Wern. Soc., viii, p. 128, 1840. Müller and Troschel. Syst. Aster., p. 77, 1842. Sladen, op. cit., p. 244, 1887. Fisher, 1911*b*, p. 105. Verrill, op. cit., p. 334, 1914*a*.

Rays five to ten, rather flat, flexible. Dorsal columnar paxillæ have lobate, articulated bases; summits either plainly paxillose or with a central spine or tubercle (spinopaxillæ), or with both kinds; largest next the lateral borders of the rays. Inferomarginal plates spinose and spinulose. Pedicellariæ often absent; when present, forceps-like, with two or three blades or valves. They are usually situated on the adambulacral plates; sometimes on the inferomarginals or peractinals.

Inferomarginal plates are transversely elongated, with wide and deep fasciolated grooves between them, bordered by slender spinules; central portion with one or more rows of spines. Superomarginals small, paxilliform, rounded. Adambulacral plates short, with one furrow-spine (rarely two); they are separated

by wide grooves. The dorsal paxillæ may be quadrate at surface and crowded, in regular rows, or stellate. Regular rows of papulæ between the rows of paxillæ. No superambulacral plates observed.

Gonads are multiple, in rows, with separate pores along the sides of the rays. Papulæ may be branched. Ambulacral ampullæ are single.

Luidia clathrata (Say) Lütken.

Asterias clathrata Say, Journ. Acad. Nat. Sci., Philad., vol. v, p. 143, 1825.

Luidia clathrata Lütken, Vidensk. Meddel., p. 37, 1859. Gray, Synopsis, p. 4, 1866. A. Agassiz, North American Starfishes, p. 117, pl. xx, 1877. (Structure.) Verrill, Notes on Radiata, Trans. Conn. Acad., vol. i, p. 271, 1867; Amer. Journ. Science, vol. iii, p. 438, 1872; ditto, vol. xlix, p. 134, 1895; Trans. Conn. Acad. Sci., vol. xi, p. 36, 1901 (habits); Starfishes of N. Pacific, pp. 7, 31, pl. 103, fig. 1, 1914*a*.

Plate xxiv; figure 2.

This is a large, five-rayed species, with long rays.

The dorsal paxillary area of the rays is rather flat or somewhat convex, wide, covered with unusually large, mostly squarish, or at least quadrangular, paxillæ which form proximally, in medium sized specimens, about ten to twelve nearly regular rows. About four or five of the lateral rows, on each side, are decidedly larger and more regular than the rest. The first three rows are nearly equal; the others decrease regularly in size; the two or three median rows are the smallest and least regular. On the disk they become more crowded, and irregularly arranged; many are hexagonal, pentagonal, or polygonal; those in the center are the smaller and more irregular, being about equal in size to the median ones of the rays. All the paxillæ are covered with numerous rather coarse, short, nearly even-topped, but unequal, spinules. On the larger lateral paxillæ there are usually from twelve to sixteen larger central spinules which are enlarged and rounded at the tips, and stand in rows of three or four, while the margins are bordered with numerous much smaller, slightly clavate spinules. On the smaller median paxillæ there are usually six to eight of the larger central spinules, surrounding one or two in the middle, thus often forming a minute rosette-form, bordered by the finer marginal spinules.

The inferomarginal plates are large; each bears two unequal,

acute, upper marginal spines; the upper one is less than half as long as the other, which is regularly tapered, often a little curved, but not flattened and very sharp; in length, the larger ones are about equal to one-fourth of the rays proximally, or equal to the width of the three adjacent rows of paxillæ. Around the bases of the large spines are a number of small acute spines.

Color in life, either gray, or salmon, or rose-salmon.

This species, like others of the genus, habitually lives concealed just under the surface of the sand. Its presence is betrayed, in shallow water, by the star-shaped impression that it forms by the action of currents of water flowing upward, through the paxillar areas, caused by ciliary action for respiratory purposes. When disturbed it glides away very rapidly, beneath the surface of the sand, by means of its large, flattened, muscular ambulacral feet, which it uses like paddles. It can also swim, by their aid, free of the sand, or on its surface.

Most common in less than 20 fathoms. Taken at 18 stations, from N. lat. 37° 31′ to 35° 12′, by the U. S. Fish Commission, in 10 to 48 fathoms. Common in shallow water from North Carolina southward to Florida and the West Indies. Rio Janeiro, Brazil. Rare north of Cape Hatteras; it has been recorded from southern New Jersey.

In the Yale Museum there are specimens from Egmont Key, W. Florida, W. T. Coons (No. 2195); Fort Macon, N. C., Dr. Yarrow (No. 4431); Rio de Janeiro, coll. C. F. Hartt (No. 5202); Cuba; etc.

Bermuda, common in sheltered situations just below low-tide level, on bottoms of shell-sand, concealed just below the surface.

All living specimens seen by me in Bermuda were either pale salmon or rose-salmon. Those from Florida and North Carolina are gray.

Luidia alternata (Say) Lütken.

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Luidia variegata Perrier, op. cit., p. 257, 1876.

Luidia granulosa Perrier, Pedicellaires, p. 109, 1869 (t. Perrier, 1876).

Rays five, a little swollen or depressed, long and fragile. It grows to rather large size, up to 325^{mm} in diameter; more often about 200^{mm}.

The dorsal paxillæ are small, rounded, and have a central spinule, longer and larger than the slender stellate ones that surround it. Four of the lateral rows of paxillæ are larger and more regular than the others with a longer middle spinule; those on the median part of the rays and on the disk are smaller, with fewer spinules. Those next to the marginals may lack the larger central spinule.

The inferomarginal plates bear two larger, long, acute, upper marginal spines, alternating in position, so as to form two series. On the lower side the plates also bear about three larger spines in a row, and many small acute ones.

The adambulacral plates bear either three or four slender spines in a transverse row, the innermost curved and smaller than the others.

The madreporic plate is usually concealed by the paxillæ.

This is a shallow-water species found mostly in sheltered localities on sandy or muddy bottoms, often just below low tide mark. Yet it extends down to 40 fathoms, off Florida (A. Agassiz), and to 88 fathoms in the Antilles (Perrier). Florida Reefs (Say); Yucatan (Ives). Off Bahia, Brazil, in 7 to 20 fathoms (Sladen).

It ranges from the coast of Florida throughout the West Indies to Bahia, Brazil. Port Royal, Jamaica, on muddy bottom near mangroves (Clark). St. Thomas, 20 fathoms (Lütken).

It was taken by the Bahama Expedition on the Great Bahama Bank (one young and two large) and near Key West, Florida.

It has not been found at the Bermudas.

I have examined the type of *Luidia variegata* Per. in the Mus. Comp. Zoölogy. It is evidently the young of this species. It was from Isle Breton, off the mouth of the Mississippi River.

Color in life: olive-green or purplish with yellowish irregular bands across the rays; under side yellow (Say). According to Nutting (Narrative, p. 166) the marginal spines of the larger specimens were chocolate-brown at the base and white at the tips.

The color in life, according to Ives, is straw-color, with three or four irregular transverse bands of blackish on the dorsal surface, not extending to the under side; spines greenish; ends

of ambulacral feet orange-red. According to Clark (1898), the color of one at Jamaica was dark olive-green or purplish above, with irregular yellowish bands across the rays; beneath yellow. Some specimens have the spines banded with lighter and darker colors.

Luidia alternata bicolor, variety nov.

Plate xii; figures 1-1*c*. Details.

The dorsal area is pretty evenly covered with small spinopaxillæ, having a small acute central spine, surrounded by a circle of about nine to twelve short clavate spinules. The spinopaxillæ are in pretty regular nearly equal longitudinal rows of twelve to fourteen or more.

The marginal plates bear three long, slender, acute, terete, bicolored spines, chocolate-brown on the basal half and pale or white distally.

The longer spines are about three times as long as the adjacent plates. The lower spine is considerably smaller and shorter than the two upper ones. It arises from near the adambulacral plates, and is sometimes lacking. The large spines are all surrounded at the base by a group of slender, very acute, small spines.

The adambulacral plates bear two slender, acute spines, one behind the other. The inner one is smaller, shorter, and curved outward. These are also surrounded at their bases by a number of small and very slender spines.

This was taken by the Bahama Expedition, off Key West, Fla., at station 39, in 20 fathoms (one large), and at station 24, in 60 fathoms (young). I have also seen it in the Albatross collections.

Luidia elegans Perrier.

Luidia elegans Perrier, Arch. Zoöl. Exper., vol. v, p. 256, 1876; Etoiles de Mer, p. 269, 1884. Verrill, Amer. Journal Sci., vol. xx, p. 403, 1880; ditto, vol. xlix, p. 134, 1895; Expl. by Albatross in 1883, p. 543, pl. xiii, figs. 39, 39*a* (distribution).

Plate xvi; figures 4, 4*a*. Details. Plate xix; figure 1. Young.

This species, as taken by us, grows to more than 350^{mm} in diameter. Color, in life, deep orange above, lighter below.

It readily detaches its rays and therefore is seldom dredged entire. It normally has five rays.

The dorsal paxillæ are stellate, much crowded, smallest in the middle of the rays; larger laterally. Each bears a circular marginal group of very slender spinules, one to three in the center, and often, in adults, one to three blunt pedicellariæ.

Inferomarginal plates have, in the adults, a vertical row of three long, tapering, acute spines, the upper ones largest. In the young usually but two spines are present.

The adambulacral plates have a transverse row of three rather slender, sharp spines; the inner one smaller and recurved; the middle one largest. A row of ovate, bilabiate pedicellariæ occurs between the inferomarginal and adambulacral plates.

The type, as described by Perrier, was young; it had the radii 5^{mm} and 35^{mm}; ratio, 1:7.

The inferomarginal plates are short, almost vertical, and bear two or three long, sharp spines, besides their spinules.

The dorsal paxillæ are nearly alike, becoming more complex toward the borders. Each has a rather short central spinule, surrounded by six to ten longer, spaced, marginal spinules, scarcely enlarged at the tip, and forming a simple stellate group, giving the paxillar area a very uniform appearance. Madreporic plate was concealed by the paxillæ.

On the actinal side there is a row of two-valved pedicellariæ, between the adambulacral and inferomarginal plates.

Perrier (1884) mentions a much larger specimen, with radii 12^{mm} and 115^{mm}, and considers the presence of *two-valved* pedicellariæ distinctive of the species.

The Bahama Expedition took, at station 63, in 85-95 fathoms, a young specimen agreeing very closely with the type, in size and most other characters. Its radii are 5.5^{mm} and 36^{mm}; ratio, 1:6.54. It has two large, nearly equal, acute spines on the marginal plates, and occasionally a third, lower down. It also has a series of small bivalve pedicellariæ external to the adambulacral plates, as in the type, so that there can scarcely be a doubt as to its identity.

It differs, however, from Perrier's description in the character of the dorsal paxillæ. Instead of being nearly uniform, they are decidedly diverse in size. The lateral row, on each side, con-

sists of stellate, round paxillæ about twice as large as those of adjacent rows, and these are in turn at least twice as large as those along the median region. The latter are very small, with few slender spinules, and much crowded.

The adambulacral plates of this specimen have three rather long, acute spines in a transverse row; the inner one, on the apex of the plate, is shorter than the others, more slender, somewhat recurved and compressed.

Large numbers of specimens, many of them of large size, were taken at about forty stations, off the eastern coast of the United States, in 1880-1887, by the United States Fish Commission steamers, mostly in 53 to 146 fathoms, from N. lat. 37° 31′ to the region south of Cape Hatteras. The Albatross also took it in the West Indies.

It was taken by the Blake, off Barbados, in 200 fathoms (Perrier). The locality of the type was not given. It was from the Mus. Comp. Zoölogy, dredged in "101 feet." Perhaps from the Hassler Expedition, off Barbados.

It was taken by the Bahama Expedition at station 63, in 85-95 fathoms, off Florida (2 spec. See pl. xix, fig. 1).

LUIDIA BARBADENSIS Perrier.

Luidia barbadensis Perrier, op. cit., p. 29, 1881. Etoiles de Mer, p. 267, pl. x, figs. 7, 8, 1884.

Plate xxiv; figure 1.

Rays flat above, slender, commonly six, sometimes five. The type had the radii 10^{mm} and 125^{mm}; ratio, 1:12.5. Greater breadth of rays about 11^{mm}.

According to Perrier the characters of the type are as follows:

Rays six, very long and extremely fragile. The three outer rows of paxillæ, on each side, have the paxillæ larger than those of the middle region; next there are two pretty regular rows of small paxillæ; the median ones are still smaller and irregularly placed.

The inferomarginal plates are covered with small spines and have a median row of larger conical spines, of which the last two are considerably larger and form the marginal row of spines.

The adambulacral plates have one furrow-spine, which is com-

pressed and slightly recurved; outside of this are two other spines equally compressed, nearly straight, and placed a little obliquely, one behind the other. Outside of these are two or three smaller and more slender spines. Some of the plates bear papilliform pedicellariæ with three valves.

The two specimens figured by Perrier (1884) have five rays. The largest one of his types, when examined by me (1896) had six broken rays. It was from station 274, off Barbados, and is probably the one described by Perrier.

It was taken by the Blake at four stations, in 40 to 209 fathoms, mostly off Barbados.

The color, in life, appears to have been red.

A specimen from the Albatross collection (No. 10,449; see pl. xxiv, fig. 1) has six rays, but all of them had been broken off near the disk and are in process of restoration, giving it the appearance of having six short, rapidly tapered and acute rays. The original parts agree very well with Perrier's types and description. Radius of the disk 10^{mm}; of the rays, as repaired, 35 to 52^{mm}.

On the repaired portions of the rays the dorsal paxillæ are smaller than on the old part, and have fewer spinules, but are otherwise similar. On the old parts the four outer rows of paxillæ are distinctly larger than the others, but not equal among themselves. Those of the outer row are roundish with a convex rosette of about ten to twelve rather stout, clavate spinules, one to three being central, besides a large number of marginal slender, fasciolated spinules. Those of the second row are transversely a little oblong, with sixteen to twenty similar spinules on top, in two series, in rosette form. Those of the third row are more nearly square with about twelve to sixteen spinules in the rosette. Those of the fourth row are somewhat smaller and have about twelve to fourteen spinules in the rosette. Those of the fifth row are decidedly smaller, nearly round, and more like those of the median area. They mostly have a regular, round, terminal rosette of seven to nine spinules, of which one or two are central. On the median area they become still smaller, with fewer spinules, and are crowded irregularly, with papulæ between them. On the repaired parts the outer row of paxillæ usually has the largest rosettes.

On the old parts the marginal plates have six or seven slender, acute spines in a transverse row. The upper one is small and sharp; the second and third are long and subequal; below these, on the inferior side, are three or four much smaller ones, in a row. Between and around the spines are numerous slender, sharp spinules.

The inner spine of the adambulacral plate is small and strongly curved; the second, on the margin, is nearly straight, about twice as large; both are compressed. The next two are smaller, acute; they stand nearly side by side, divergent. Outside of these is a rather large, conical, erect pedicellaria on many of the plates. Most of them have three valves; some only two.

Similar three-valved pedicellariæ of larger size occur on the interradial areas; four or five on each.

Station 2403, off West Florida, in 88 fathoms (No. 10449).

Luidia convexiuscula Perrier.

Luidia convexiuscula Perrier, op. cit., 1881, p. 30; Etoiles de Mer, p. 268, pl. x, fig. 6,[27] 1884.

A very slender six-rayed species. The type has the radii 5^{mm} and 28^{mm}; ratio, 1:5.6.

Perrier gives the following characters:

Dorsal surface slightly convex, with the paxillæ almost equal, but a little smaller upon the median part of the rays and on the disk. They bear small, nearly equal, divergent spinules; the central ones are a little larger than the rest, but are not prolonged into a spine. There are about fifteen rows of paxillæ.

The inferomarginal plates are short, covered with small spines, and bear a single long marginal spine.

The adambulacral plates have one long, compressed, recurved furrow-spine, and outside of it a cluster of smaller spines.

Perrier recorded this species from six Blake stations, in 56 to 208 fathoms, among the Lesser Antilles, and in one station, in the Gulf of Mexico, in 101 fathoms.

Some of these specimens were examined by me in 1896.

[27] The references to the figures of this and the preceding species were incorrectly given by Perrier (1884) in his text.

LUIDIA MARCGRAVII Lütken.

Luidia marcgravii (Steenstrup MSS.) Lütken, op. cit., 1859, p. 43. Verrill, op. cit., 1867, p. 343.

Stella marina, Marcgrave, Hist. Rerum nat. Brazil, viii, p. 189, 1648.

Asterias 4. "The large starfish with eight or more slender arms" Browne, Civil and Nat. Hist. Jamaica, 393, 1756.

Luidia senegalensis (*pars*) Müll. and Trosch., Syst. Aster., p. 78, 1842 (*non* Lam.). Perrier, Revision, p. 262, 1876. R. Rathbun, op. cit., p. 149, 1879.

A large species, up to 360^{mm} in diameter, with a disk of 51^{mm}, almost always with nine slender, flattened, narrow rays; rarely eight. It is very fragile like most other species of the genus.

The larger lateral paxillæ are triseriate, rectangular, covered with about fifteen obtuse, central granules, surrounded by numerous setiform marginal spinules. The paxillæ in the median radial area are much smaller and minute.

A triangular area, bearing paxillæ, is intercalated in the interradial area, between the second and first rows of lateral paxillæ.

The inferomarginal plates are densely covered with short flat spines, larger centrally, and bear two larger, short, biserial, marginal spines. Adambulacral plates bear three or four compressed spines, the two inner ones curved.

The color, in life, according to Clark, is greenish or grayish above, yellow below, much as in *L. clathrata*, from the same places.

Our dried specimens are light gray with a darker bluish gray medial stripe, on each ray. Both have nine rays.

Perrier (1876) states that he has compared specimens from W. Africa with others from Brazil and Guadeloupe and found no differences.

Lütken, however, made a very careful study of the American species and found it distinct, though nearly allied. He was certainly a very expert authority on starfishes.

Personally I have not been able to study a sufficient number of specimens from both regions to warrant any decided opinion. It is generally admitted that some other species of Echinoderms are common to the W. African and American seas.

Originally this species was recorded from Brazil by Marc-

grave (1648), and a century later, by Browne (1756) from Port Royal and Kingston, Jamaica, where it has recently been found by Clark, in very shallow water, at Port Royal. Cotinguiba, Brazil, and San Domingo (Lütken). Pernambuco, Brazil, abundant (Rathbun), and Yale Mus., coll. C. F. Hartt, No. 5,201.

I do not know that it has been taken on the Florida coasts, or at the Bahamas. It seems to abound most on the tropical coast of Brazil. The Yale Museum has a cotype from Brazil, No. 1,343, sent by Lütken.

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———. Revision of Certain Genera and Species of Starfishes, with Descriptions of New Forms. Trans. Conn. Acad. of Arts and Sciences, vol. x, part i, pp. 145-234, pls. xxiv*a*-xxx, New Haven, 1899.

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Eight new genera established.

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———. Review in Science, vol. xl, no. 1032, pp. 523-525, Oct. 9, 1914; and in Amer. Journ. Science, vol. xxxviii, p. 107, 1914, with errata.

———. Nomenclature of Certain Starfishes. Amer. Journal Science, vol. xxxvii, p. 483, May, 1914*b*. Treats of *Anseropoda luna* (L.); *Acanthaster planci* (L.).

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LIST OF SPECIES HEREIN DESCRIBED OR FIGURED

Those prefixed by an asterisk (*) were taken by the Bahama Expedition. Those with a dagger (†) are extralimital, or from deep water.

Family Asteriidæ

* Orthasterias subangulosa Verrill, nom. nov. Pl. ii, figs. 1, 2; pl. ix, figs. 1, 1*a*
O. contorta (Per.)
Leptasterias fascicularis (Per.)
L. hartii Rathbun
L. mexicana (Lütken)
Coscinasterias linearis (Per.)
C. tenuispina (Lam.). Pl. xxvi, fig. 2; pl. xxvii, fig. 4
* Stephanasterias gracilis (Per.). Pl. ix, fig. 2-2*c*
S. hebes Ver. nov. Pl. ix, fig. 3. Type

Family Zoroasteridæ

Zoroaster ackleyi Per.

Family Pedicellasteridæ

* Coronaster briareus Ver. Pl. i, figs. 1, 2; pl. ix, figs. 4-4*c*
* Pedicellaster pourtalesii Per.

Family Echinasteridæ

* Echinaster sentus (Say). Pl. xxix, fig. 2
E. spinulosus Ver. Plate iv, figs. 1, 2. Types
E. braziliensis M. and Tr. Pl. xxvi, fig. 1
E. echinophorus (Lam.)
E. modestus Per.
Thyraster serpentarius (M. and Tr.)
Henricia antillarum (Per.)
* H. sexradiata (Per.). Pl. xi, fig. 7
H. microspina Ver. nov.

Family Solasteridæ

* Lophaster radians Per. Pl. v, fig. 2; pl. vii, fig. 3; pl. xi, figs. 1-1*c*
Solaster caribæus Ver., nov. Pl. xxviii, figs. 1-1*a*. Type

Family Korethrasteridæ

* Remaster palmatus Per. Pl. xi, fig. 2

Family Asteriniidæ

† Asterina gibbosa (Penn.)
* Asterinides folium (Lütken). Pl. iii, fig. 5; pl. xi, fig. 4; pl. xxviii, fig. 2
† Asterinides modesta Ver. Pl. xxvii, figs. 1, 2. Types
Enoplopatiria marginata. Pl. vii, fig. 2. Brazil

† E. siderea Ver. Pl. xxvii, figs. 3-3*a*
Asterinopsis pilosa (Per.)
A. lymani (Per.)
* Stegnaster wesseli (Per.). Pl. iii, figs. 3-3*a*

Family Poraniidæ
† Rhegaster spinulosus Verrill
† R. borealis Verrill. Pl. x, figs. 3, 3*a*. Type.
Poraniella regularis Verrill. Pl. vii, figs. 1-1*a*; pl. xv, figs. 5-5*b*. Types
P. echinulata (Per.)
Marginaster pectinatus Perrier
Porania (?) austera Verrill. Pl. iii, figs. 1-1*a*; pl. xi, figs. 6, 6*a*. Types
† Poranisca lepidus Ver. Types. Pl. iv, figs. 3-7; pl. x, figs. 4-4*a*; pl. xv, fig. 6. See op. cit., 1914*c*
† Culcitopsis borealis (Suss. & Breckner) Ver.

Family Pterasteridæ
Pteraster caribbæus Perrier. Pl. vii, fig. 4

Family Ophidiasteridæ
Ophidiaster guildingii Gray
O. floridæ Perrier
O. alexandri Ver., nov. Pl. xiii, figs. 3-3*b*; pl. xxv, fig. 2. Type
* Linckia nodosa Per. Pl. xiii, figs. 2, 2*a*; pl. xxix, figs. 1*a*, 1*b*
L. guildingii Gray. Pl. xxviii, fig. 3
Narcissia trigonaria Sladen

Family Oreasteridæ
* Oreaster reticulatus (Linn.)

Family Goniasteridæ
* Goniaster americanus Ver. Pl. xiii, figs. 5-5*a*. Type
Mediaster pedicellaris (Per.)
* Rosaster alexandri Perrier. Pl. xvii, fig. 2; pl. xi, figs. 3-3*b*
* Anthenoides peircei Perrier. Pl. iii, fig. 2; pl. x, figs. 1-1*b*; 2-2*f*

Family Chætasteridæ
* Chætaster nodosus Perrier. Pl. viii, figs. 1, 2; pl. xiii, figs. 4-4*c*
C. longipes (?) Sladen

Family Odontasteridæ
Odontaster hispidus Ver. Pl. xiii, fig. 6.

Family Benthopectinidæ
* Cheiraster mirabilis Perrier. Pl. xiv, figs. 5, 5*a*
C. mirabilis coronatus (Per.)
* C. echinulatus Per. Pl. xiv, fig. 3; pl. xix, fig. 2; pl. xxv, fig. 1
† C. planus Ver. nov. Pl. xviii, fig. 2. Type
† C. enoplus Ver. nov. Pl. xviii, fig. 1. Type
Pectinaster vincenti Per.

* P. mixtus Ver. nov. Pl. xv, fig. 2; pl. xvii, fig. 1; pl. vi, fig. 2. Type
* P. gracilis Ver. nov. Pl. vi, fig. 1; pl. xv, figs. 1-1*b*; pl. xiv, fig. 4. Type
P. oligoporus Per.
P. dispar Ver. nov. Pl. xiv, figs. 1-1*b*. Type
† Pectinaster (Pontaster) forcipatus (Sladen). Pl. xv, figs. 3, 4. Young
† Pontaster sepitus Ver. See foot-note, p. 130.

Family Astropectinidæ

* Astropecten articulatus (Say)
A. articulatus dubius (Gray)
A. duplicatus Gray. Pl. xxii, fig. 2; pl. xxiii, fig. 1.
A. duplicatus variabilis (Lütken). Pl. xvi, figs. 2, 2*a*; pl. xxiii, fig. 2
A. antillensis Lütken
A. braziliensis M. and Tr.
A. comptus Ver. nov. Pl. xii, figs. 3-3*c*; pl. xxii, fig. 1
A. richardi Per.
A. cingulatus Sladen
A. nitidus Ver. nov. Pl. xx, fig. 2
A. nitidus forcipatus Ver. nov. Pl. xvi, fig. 3; pl. xx, fig 1
A. alligator Per.
* A. nuttingii Ver. nov. Pl. xii, figs. 2-2*e*; pl. xxi, figs. 1, 2
A. americanus Ver. Pl. xvi, figs. 1, 1*a*
A. americanus subgracilis Ver. nov.
A. ciliatus Grubé
* Blakiaster conicus Per. Pl. iii, fig. 4; pl. xi, fig. 5; pl. xiii, figs. 1-1*c*
Sideriaster grandis Ver. Pl. xii, figs. 5-5*b*. Type
† S. (?) vestitus (Say)
† Plutonaster intermedius Per.

Family Goniopectinidæ

Prionaster elegans Ver. Pl. xii, figs. 4-4*c*. Type

Family Luidiidæ

* Luidia clathrata (Say). Pl. xxiv, fig. 2
* Luidia alternata (Say)
* Luidia alternata bicolor Ver. nov. Pl. xii, figs. 1-1*c*
Luidia elegans Per. Pl. xvi, figs. 4, 4*a*; pl. xix, fig. 1
Luidia barbadensis Perrier. Pl. xxiv, fig. 1
Luidia convexiuscula Perrier
Luidia marcgravii Lütken. Pl. v, fig. 1. Cotype

LIST OF DEEP SEA SPECIES NOT DESCRIBED IN THIS REPORT

Family Brisingidæ

Hymenodiscus agassizii Perrier, 1881; 1884; 1894, pp. 45, 52; 391-450 fath.

Freyella, sp. near F. sexradiata

Brisinga cricophora Sladen, 1859. Off Bermuda; 390 fath.

Brisinga, near *B. costata*

Brisinga, near *B. elegans*

Family Zoroasteridæ

Mammaster sigsbei Per., 1881; 1884; 1894, p. 125; 208-324 fath.

Zoroaster fulgens Sladen, off Brazil, 675 fath.; off E. N. Amer. coast, 1250-1350 fath.

Family Solasteridæ

Radiaster elegans Per. 1881; 1884; 1894, p. 174; 982 fath.

Ctenaster spectabilis Per. 1881; 1884; 1894, p. 155; 1920 fath. Probably the same as Pteraster spectabilis Perrier in lists (without description).

Family Pterasteridæ

Hymenaster, sp.

Hymenaster, sp.

Calyptraster coa Sladen, 1889, p. 489, pl. 78, 79. Off Brazil, 132-400 fath.

Family Ophidiasteridæ

Fromia, sp.

Family Goniasteridæ

Ceramaster grenadensis (Per.) Verrill, 1899, p. 162; 176 fath.

Plinthaster comptus Ver., 1899, p. 163, pl. xxvii, fig. 2, 555-683 fath.

Plinthaster nitidus Ver., 1899, p. 165, pl. xxvii, fig. 1-1*b*; 335 fath.

Pyrenaster dentatus (Per.) Verrill, 1899, p. 167, pl. xxvii, fig. 3-3*b*; 250-1639 fath.

P. affinis? (Per.) Verrill, 1899, p. 168; 1131-1323 fath.

Peltaster nidarosiensis (Storm.) = *P. hebes* Ver., 1899, p. 169. See pl. xxviii, fig. 4, 4*a*; 294 fath.

Litonotaster intermedius (Per.) Verrill, 1899, p. 172, pl. xxviii, figs. 5-5*b*, 1467-1930 fath.

Hippasteria caribæa Ver., 1899, p. 174, pl. xxviii, fig. 1, 1*a*; 268 fath.

Cladaster rudis Ver., 1899, p. 176, pl. xxviii, figs. 2-2*c*; 440 fath.

Mediaster agassizii Ver., 1899, p. 181

Nymphaster ternalis (Per.) Verrill, 1899, p. 185, pl. xxvi, fig. 7; 196-1181 fath.

N. subspinosus (Per.), 1881, 1884; Verrill, 1879, p. 185; 163-388 fath.
N. arenatus (Per.), 1881, 1884; Verrill, 1899, p. 186; 164-874 fath.
N. basilicus Sladen, 1859, p. 308, pl. lvii, figs. 8, 9; Brazil, 1200 fath.
Pseudarchaster hispidus Ver., 1889, p. 191, pl. xxx, fig. 5; 600 fath.
P. ordinatus Ver., 1899, p. 194, pl. xxx, figs. 4-4*b*; 324-335 fath.
P. granuliferus Ver., 1899, p. 192; pl. xxx, fig. 6, 6*a*. Sta. 2751.
Paragonaster subtilis (Per.), 1881; 1894, p. 358; Verrill, 1899, p. 196; 1930 fath.
Plutonaster intermedius (Per.), 1881; 1894, p. 316, des.; 833-955 fath.
P. efflorescens (Per.), 1884; 1894, p. 322; Verrill, 1899, p. 211; 955 fath.
P. pulcher (Per.), 1881; 1884; 1894, p. 332; 573 fath.
Dytaster insignis Per., 1881; 1884; 1894, p. 299, des.; 1930 fath.
Dytaster sp., near D. robustus Ver.

Family ODONTASTERIDÆ
Odontaster sp., near O. setosus Ver.
Odontaster sp., compact species

Family BENTHOPECTINIDÆ
Benthopecten simplex (Per.), 1881; 1894, p. 254, descr.; 1323 fath.

Family GONIOPECTINIDÆ
Goniopecten demonstrans Per., 1881; 1884; 1894, p. 295; Verrill, 1899, p. 213, pl. xxvii, fig. 5; 335-358 fath.

Family ASTROPECTINIDÆ
Psilaster sp., near P. floræ Ver.
Leptychaster, sp.

Family PORCELLANASTERIDÆ
Porcellanaster cœruleus Sladen
Ctenodiscus crispatus? (Retz.)

EXPLANATION OF PLATES

PLATE I

Figure 1. *Coronaster briareus* Verrill. Dorsal side, × 1½

Figure 2. The same specimen. Ventral side, × 1½

PLATE II

Figure 1. *Orthasterias subangulosa* Ver. Ventral side, × 2

Figure 2. The same specimen. Dorsal side, × 2

PLATE III

Figure 1. *Porania* (?) *austera* Ver. Type. Ventral side, × 1⅗

Figure 1*a*. The same specimen. Dorsal side, × 1⅗

Figure 2. *Anthenoides peircei* Per. Young. Ventral side. Much enlarged

Figure 3. *Stegnaster wesseli* (Per.). Ventral side, × 1⅖

Figure 3*a*. The same. Dorsal side, × 1⅖

Figure 4. *Blakiaster conicus* Per. Ventral side, × 1⅙

Figure 5. *Asterinides folium* (Lutk.). Ventral side, × 2¼

PLATE IV

Figure 1. *Echinaster spinulosus* Verrill. From West Florida. Under side, natural size. Type

Figure 2. The same, No. 7395, Yale Mus. Dorsal side, natural size

Figures 3-7. *Poranisca lepidus* Ver. Cotypes. Young of several sizes; dorsal and ventral sides; all from one locality. See Annals and Magazine Nat. Hist., vol. xix, page 19, pl. 1, fig. 3, Jl., 1914*c*. See also pl. x and pl. xv, below.

PLATE V

Figure 1. *Luidia marcgravii* Lütken. No. 1343, Yale Mus. Cotype from Lütken. Dorsal side. About ½ natural size.

Figure 2. *Lophaster radians* Per. Bahama Exped., station 64. Ventral side of an alcoholic specimen, × 2¼. See also pl. vii, fig. 3 and pl. xi, figs. 1-1*c*.

PLATE VI

Figure 1. *Pectinaster gracilis* Ver. Type. No. 10,564. Dorsal side, × 2

Figure 2. *Pectinaster mixtus* Ver. Type. No. 10,226. Dorsal side, × 2

PLATE VII

Figures 1, 1*a*. *Poraniella regularis* Ver. Type. No. 10,190 N. M. Dorsal and ventral sides, × 1½. See also pl. xv, figs. 5, 5*a*, details

Figure 2. *Enoplopatiria marginata* Hupé, from Brazil. Dorsal side, × 1¾. No. 1341, Yale, from Lütken.

Figure 3. *Lophaster radians* Per. Dorsal side, ½ natural size.

Figure 4. *Pteraster caribbæus* Per. No. 18,415, N. Mus. Ventral view, × 2

Plate VIII

Figure 1. *Chætaster nodosus* Perrier. Ventral view. About 4/5 natural size.

Figure 2. The same specimen. Dorsal view, 4/5 natural size.

Plate IX

Figure 1. *Orthasterias subangulosa* Verrill. Under side of middle of a ray, × 5

Figure 1*a*. The same specimen. Dorsal side, × 5

Figures 2, 2*a*. *Stephanasterias gracilis* (Perrier). Under side of portions of a ray, × 10

Figure 2*b*. The same. Dorsal side, × 10

Figure 2*c*. The same. Jaw and under side of disk, × 10

Figure 3. *S. hebes* Verrill, nov. Type (No. 18,426). Under side of portion of a ray, × 10

Figure 4. *Coronaster briareus* Verrill. Dorsal side of disk and bases of rays. of a specimen from station 61, Bahama expedition; × 5

Figure 4*a*. The same specimen. Under side of bases of three rays and jaws of an alcoholic specimen; × 10

Figure 4*b*. The same. Two of the dorsal spines with groups of minor pedicellariæ, × about 30

Figure 4*c*. The same. One of the large felipedal pedicellariæ. Much enlarged

Plate X

Figure 1. *Anthenoides peircei* Perrier. Under side of a portion of a very young specimen, same as plate iii, figure 2; × 3

Figure 1*a*. The same specimen. Dorsal side, × 3; *n*, nephridial or dorsal pore.

Figure 1*b*. The same specimen. Adambulacral spines, × 7.

Figures 2, 2*a*. The same species. Under side of a ray of a young specimen, but considerably older than that of figure 1; × 3

Figures 2*b*, 2*c*. The same. Dorsal side of a ray, × 3

Figure 2*d*. The same specimen. Adambulacral spines, × 7

Figure 2*e*. The same. Adambulacral spines in profile; *f*, furrow-comb; *e*, row on actinal face; × 7

Figure 2*f*. The same specimen. Two bivalve pedicellariæ, P,P′, and adjacent interactinal plates; × 18

Figure 3. *Rhegaster borealis* Verrill. Type. No. 343. Yale. Part of the ventral side of a ray, × 5

Figure 3*a*. The same specimen. Group of dorsal papular pores, × 8

Figures 4, 4*a*. *Poranisca lepidus* Verrill. Type. Station 2269. Ventral and dorsal sides, × 5

Figure 4*b*. The same. One of the inferomarginal plates and group of spinules. See also pl. iv, figs. 3-7.

PLATE XI

Figure 1. *Lophaster radians* Perrier. Portion of dorsal side of a ray × 3.

Figure 1*a*. The same specimen. Under side of portion of a ray of an alcoholic specimen; *po,* podia; *a,* adambulacral spines; *i,i,* inferomarginals; *m,* superomarginals; × 5

Figure 1*b*. The same. One of the dorsal parapaxillæ; × 16

Figure 1*c*. The same. Adambulacral spines of one plate; × 16

Figure 2. *Remaster palmatus* Perrier. Dorsal view of a part of the disk and two rays, × 6. Many of the dorsal spines are removed, to show plates; *p,* dorsal pore

Figure 3. *Rosaster alexandri* Perrier. Part of disk and two rays of a young specimen, dorsal view; *p,* dorsal pore; *i,i,* large basal interradial plates; *m,* madreporic plate. The spinules are partly removed to show form of plates; × 3.

Figure 3*a*. The same. Two of the dorsal plates with rosettes of spinules, × 16.

Figure 3*b*. The same. Two of the dorsal spinules more enlarged.

Figure 4. *Asterinides folium* (Lütk.) Dorsal view of a six-rayed specimen, about natural size.

Figure 5. *Blakiaster conicus* Perrier. Under side of disk and jaw of the specimen on plate *iii,* figure 4, Bahama Exped.; spinules are removed from part of the plates; *j,* jaw-plate; *a, a,* adambulacral plates; a^1, a^1, adoral adambulacral plates, one with spines; *ia*, ia^1, interactinal plates; *o*, o^1, o^{11}, impaired interactinal plates; *p,* pit where a pedicellaria was seated. × 5.

Figure 6. *Porania austera* Verrill. Type. Dorsal view of portion of disk at base of rays; *s, s,* superomarginal plates; *i, i,* inferomarginal plates; *j, j* their secondary row of spinules. × 5.

Figure 6*a*. The same specimen. Under side of a portion of the disk and base of a ray. × 5.

Figure 7. *Henricia sexradiata* (Perrier). Under side of a ray. Specimen from Bahama Expedition; *m,* inferomarginal plates; *i,* interactinals; *a,* adambulacrals; *s, s,* adambulacral spines. × 16.

PLATE XII

Figures 1, 1*a*. *Luidia alternata bicolor* Verrill. Type. Dorsal and ventral views of a part of a ray. × 3.

Figures 1*b*. The same. Section of a ray; diagramatic; *a, a,* ambulacral single ampullæ; *p,* podia; *ap,* ambulacral plates; *ad,* adambulacral plate and spines; *m,* marginal plate and spines; *pa,* dorsal paxillæ.

Figure 1*c*. The same. One of the marginal spines; the shaded portion is chocolate-brown; the unshaded distal part is white. × 13.

Figure 2. *Astropecten nuttingi* Verrill. Type. Dorsal side of proximal part of a ray. × 6.

Figure 2*a*. The same specimen. Under side of portion of a ray. × 10. From Bahama Expedition. Station 58.

Figure 2*b*. The same. Diagram of profile of a border of a ray.

Figure 2*c*. The same. Dorsal side of a superomarginal plate (*m*) and projecting border of the inferomarginal plates (*i*, *i*) and bases of spines. × 13.

Figure 2*d*. The same. One of the dorsal paxillary rosettes. × 16.

Figure 2*e*. The same. Three rosettes more enlarged. × 24.

Figure 3. *Astropecten comptus* Verrill. Type. (No. 8,514, N. Mus.) Dorsal view of portion of a ray. × 4.

Figure 3*a*. The same specimen. Under side of portion of a ray. × 4.

Figure 3*b*. The same. One of the fasciolated grooves between the inferomarginal plates. × 10.

Figure 3*c*. The same. Two of the dorsal paxillary rosettes. × 24.

Figure 4. *Prionaster elegans* Verrill. Type. Under side of a part of the disk and base of a ray. × 4½.

Figure 4*a*. The same specimen. Under side of a part of the disk and base of a ray. × 4½.

Figure 4*b*. The same specimen. Tip of a ray. × 6.

Figure 4*c*. The same. One of the dorsal paxillary rosettes, enlarged.

Figure 5. *Sideriaster grandis* Verrill. Type. Under side of portion of a ray. × 4.

Figure 5*a*. The same specimen. An adambulacral plate and its spines. × 6.

Figure 5*b*. The same. One of the dorsal paxillary rosettes. × 4½.

Plate XIII

Figure 1. *Blakiaster conicus* Perrier. Portion of the proximal part of a ray, under side; *ad*, adambulacral plates and spines; *ia*, interactinals; *m*, inferomarginals. × 10.

Figure 1*a*. The same. Dorsal plates and papulæ after removal of spinules. × 12.

Figure 1*b*. The same specimen. A superomarginal plate and adjacent dorsal paxillæ. × 10.

Figure 1*c*. The same. Two of the papilliform pedicellariæ (*p*), much enlarged.

Figure 2. *Linckia nodosa* Perrier. Dorsal side of a ray. × 4.

Figure 2*a*. The same specimen. Ventral side of part of a ray. × 4.

Figure 3. *Ophidiaster alexandri* Verrill. Type. Dorsal side of part of a ray. × 4.

Figure 3*a*. The same specimen. Under side of part of a ray. × 4.

Figure 3*b*. The same specimen. Under side of a portion of a ray with spinules removed to show plates; *a*, adambulacral plates; a^1, adambulacral spines; *i*, *i*, interactinal plates, in three rows; *m*, *m*, inferomarginals; m^1, m^1, superomarginals. × 4.

Figure 4. *Chætaster nodosus* Perrier. Portion of under side of a ray; *ad*, adambulacral plates; *m*, marginal plate. × 16.

Figure 4*a*. The same specimen. Portion of the dorsal side of the base of a ray. × 16.

Figure 5. *Goniaster americanus* Verrill. Portion of the under side of the disk, with the jaw. × 4½.

Figure 5*a*. The same. Dorsal plates, with fossate pedicellariæ. × 20.

Figure 6. *Odontaster hispidus* Verrill. Portion of dorsal side of a ray; *p*, dorsal parapaxillæ; *m*, superomarginal plates; *v*, *v*, inferomarginal spines. × 6.

PLATE XIV

Figure 1. *Pectinaster dispar* Verrill. Type. No. 18,468. Part of under side of a ray; plates 6 to 9. × 5.

Figure 1*a*. The same specimen. Papularium. × 15.

Figure 1*b*. The same specimen. Portion of the dorsal side of a ray. × 5.

Figure 2. *Cheiraster mirabilis* Perrier. Part of a ray, under side. × 7. Station 2, Bahama Expedition.

Figure 3. *C. echinulatus* Perrier. No. 10,109. N. Mus. Part of disk, under side. × 8.

Figure 4. *Pectinaster gracilis* Verrill. Sta. 238. Portion of under side of a ray. × 10.

Figure 5. *Cheiraster mirabilis* Perrier. From station 34, Bahama Expedition. Part of disk and base of a ray, showing papularium. × 5.

Figure 5*a*. The same specimen. Portion of under side of a ray. × 5.

PLATE XV

Figure 1. *Pectinaster gracilis* Verrill. Cotype. Young. Sta. 238. Part of under side of the disk showing one sutural pectinate pedicellaria between two interactinal plates. × 9.

Figure 1*a*. The same specimen. Upper side of distal portion of a ray, with spinules removed from dorsal plates. × 9.

Figure 1*b*. The same specimen. Base of ray and papularium in early stage of development with only three pores. × 15.

Figure 2. *Pectinaster mixtus* Verrill. Cotype. Distal part of a ray with the spinules removed from part of the plates. × 6.

Figure 3. *Pectinaster forcipatus* (Sladen). No. 18,488. Papularium of a young specimen; *d*, dorsal pore. × 12.

Figure 4. The same species, No. 18,488*a*, N. Mus. Papularium with the spinules removed from plates. × 12.

Figure 5. *Poraniella regularis* Verrill. Type. No. 10,190. Nat. Mus. Under side of two rays and part of disk. × 6.

Figure 5*a*. The same specimen. Dorsal side of a ray; *s*, superomarginal plates; *i*, inferomarginals; *j*, secondary row of spines on the latter.

Figure 5*b*. The same. Adambulacral spines of one plate; *f*, furrow-comb of three spines; *e*, *e*, two spines of actinal face.

Figure 6. *Poranisca lepidus* Ver. Type. One of the jaws. × 10.

PLATE XVI

Figure 1. *Astropecten americanus* Verrill. No. 25,149. N. Mus. Under side of part of disk and a jaw, showing papilliform pedicellariæ (*P*, *P*) on adambulacral plates. × 7.

Figure 1*a*. The same specimen. Part of dorsal side of a ray, near base. × 7.

Figure 2. *A. duplicatus variabilis* (Lütken). Type. No. 2,084, Yale Mus. Portion of a ray, 4th to 6th plates, dorsal side. × 9.

Figure 2*a*. The same specimen. Under side of portion of a ray. × 9.

Figure 3. *A. nitidus forcipatus* Verrill. Type. No. 10,067, N. Mus. Portion of under side of a ray. × 7.

Figure 4. *Luidia elegans* Perrier. No. 5,525, Yale Mus. Portion of under side of a ray. × 7.

Figure 4*a*. The same specimen. Portion of the dorsal side of a ray. × 7.

PLATE XVII

Figure 1. *Pectinaster mixtus* Verrill. Young, (No. 18,470). Dorsal side. × 3.

Figure 2. *Rosaster alexandri* Perrier. Dorsal side. × 3, off Havana. Bahama Expedition. Some plates are lacking.

PLATE XVIII

Figure 1. *Cheiraster enoplus* Verrill. Type. No. 7,425, N. Mus. Dorsal side; 3/5 natural size.

Figure 2. *C. planus* Verrill. Type. No. 18,469, Nat. Mus. Dorsal view. × 1 1/5.

PLATE XIX

Figure 1. *Luidia elegans* Perrier. Young. Dorsal view. × 3½. Bahama Expedition, station 63.

Figure 1. *Astropecten nuttingi* Ver., sp. nov. Type. Bahama Exped., tion, station 61. × 3½.

PLATE XX

Figure 1. *Astropecten nitidus forcipatus* Ver., nov. Type, No. 10,067. Dorsal side. × 1 2/5.

Figure 2. *A. nitidus* Ver. Type, No. 18,344, Nat. Mus. × 1 2/5.

PLATE XXI

Figure 1. *Astropecten nuttingii* Ver., sp. nov. Type. Bahama Exped., sta. 64. Dorsal side. × 1 1/5.

Figure 2. The same specimen. Under side. × 1⅓.

PLATE XXII

Figure 1. *Astropecten comptus* Ver. Type, No. 18,346, Nat. Mus. Dorsal side. 7/10 natural size.

Figure 2. *A. duplicatus* Gray. No. 10,989, Nat. Mus. Dorsal side. 7/10 natural size.

PLATE XXIII

Figure 1. *Astropecten duplicatus* Gray. St. Thomas. From Lütken. Dorsal view. × 1¼.

Figure 2. The same, var. *variabilis* (Lütken). Cotype, from Lütken. Ventral view. × 1¼. No. 2,084, Yale Museum.

Plate XXIV

Figure 1. *Luidia barbadensis* Perrier. Dorsal view. No. 10,449, N. Mus. × 1 4/5.

Figure 2. *Luidia clathrata* (Say). From Bermuda. Dorsal view. × 3.

Plate XXV

Figure 1. *Cheiraster echinulatus* (Per.) Ventral side; × 2.

Figure 2. *Ophidiaster alexandri* Ver. Type. Dorsal side. Natural size.

Plate XXVI

Figure 1. *Echinaster braziliensis* M. and Trosch. Ventral side. Natural size. Specimen from Brazil.

Figure 2. *Coscinasterias tenuispina* (Lam.) Var. Dorsal side of a seven-rayed, living, Bermuda specimen under water; ¾ natural size.

Plate XXVII

Figures 1, 2. *Asterinides modesta* Ver. Types. Ventral and dorsal views of type specimens; × 3.

Figure 3. *Enoplopatiria siderea* Ver. Type. Ventral view of part of the disk and a ray, with part of the spinules removed; × 2½.

Figure 3*a*. The same specimen. Dorsal view of a part of a ray and disk. Spinules are partly removed from the plates of the ray; × 2½.

Figure 4. *Coscinasterias tenuispina*. Dorsal view of a living specimen under water. About natural size.

Plate XXVIII

Figure 1. *Solaster caribæus* Ver. Dorsal side of a small specimen; somewhat enlarged.

Figure 1*a*. The same specimen. Ventral side; more enlarged.

Figure 2. *Asterinides folium* (Lütk.). Dorsal side; × 4.

Figure 3. *Linckia guildingii* Gray. Dorsal side of a young specimen, repproducing rays, after autotomy. Natural size.

Figure 4. *Peltaster nidariosensis* Storm = *P. hebes* Verrill, type. Ventral side; ⅔ nat. size.

Figure 4*a*. The same specimen. Group of plates on the dorsal side of the disk, with most of the granules removed. Much enlarged.

Plate XXIX

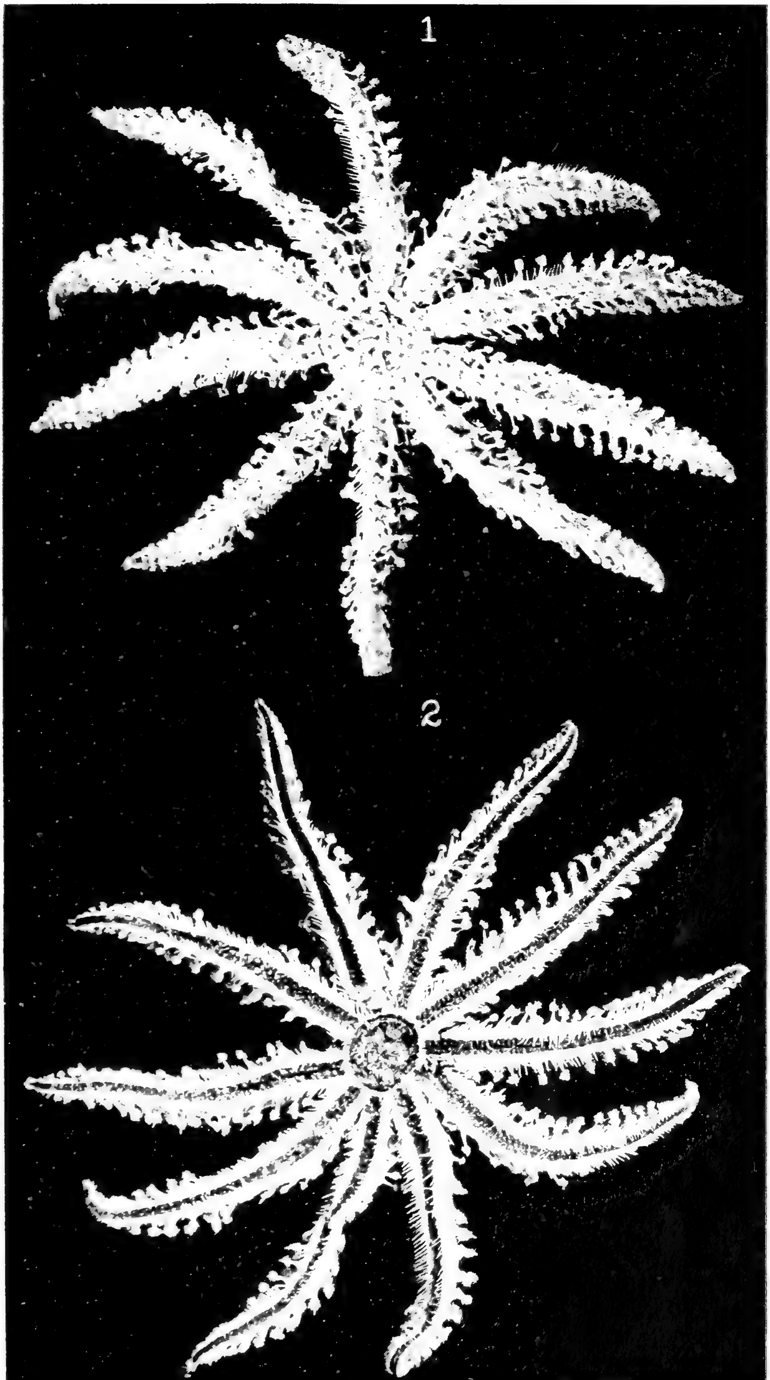
Figure 1. *Linckia nodosa* Per. Dorsal side; × 1⅕.

Figure 1*a*. The same specimen. Ventral side; × 1⅕.

Figure 2. *Echinaster sentus* V. (?) Young. About natural size. Bahama Expedition.

SYSTEMATIC INDEX

The references are to formal descriptions. Synonyms are not included



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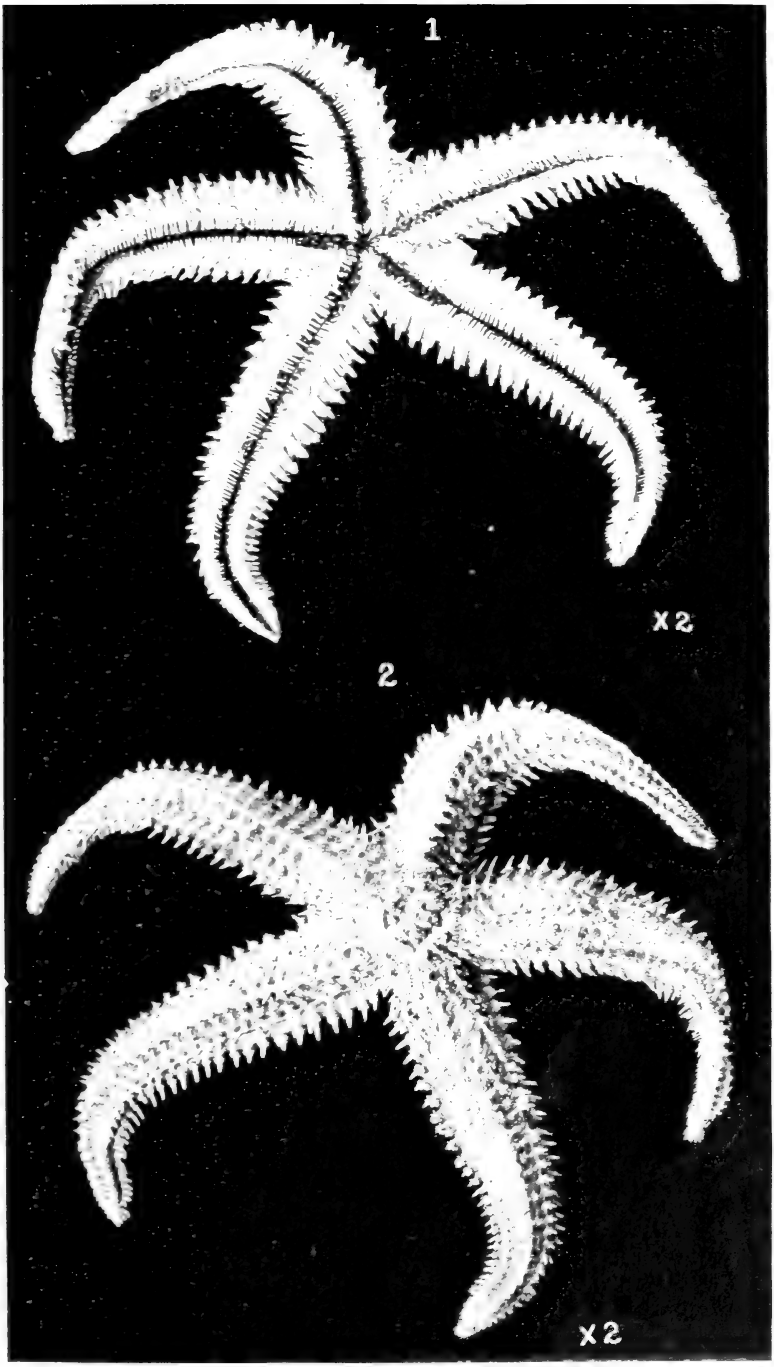

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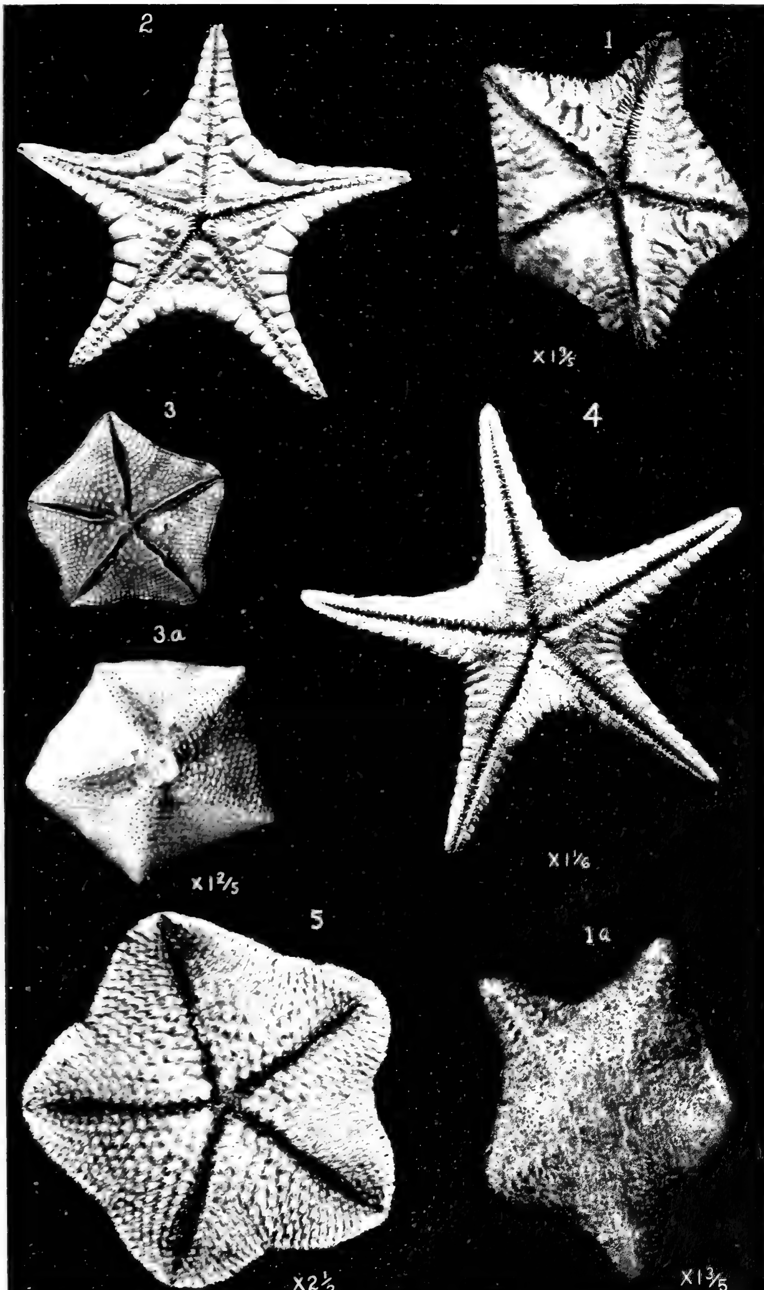

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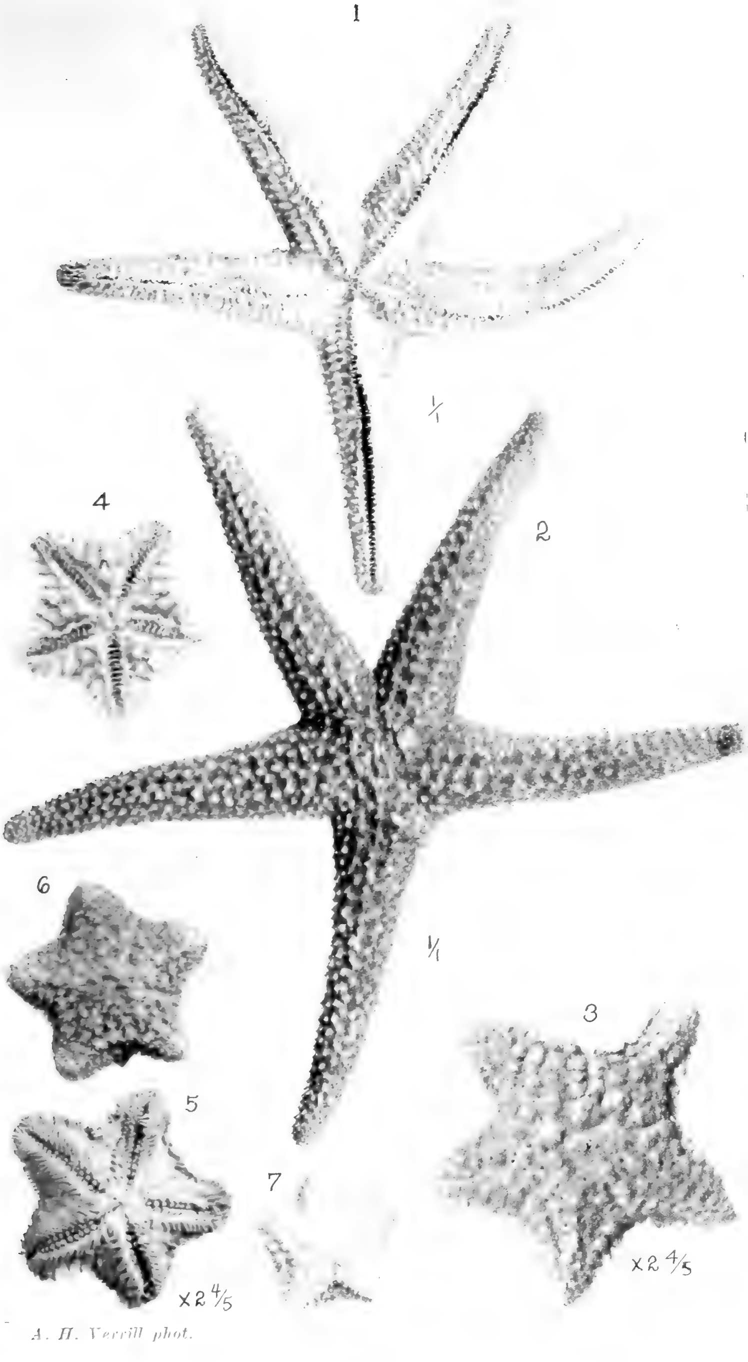

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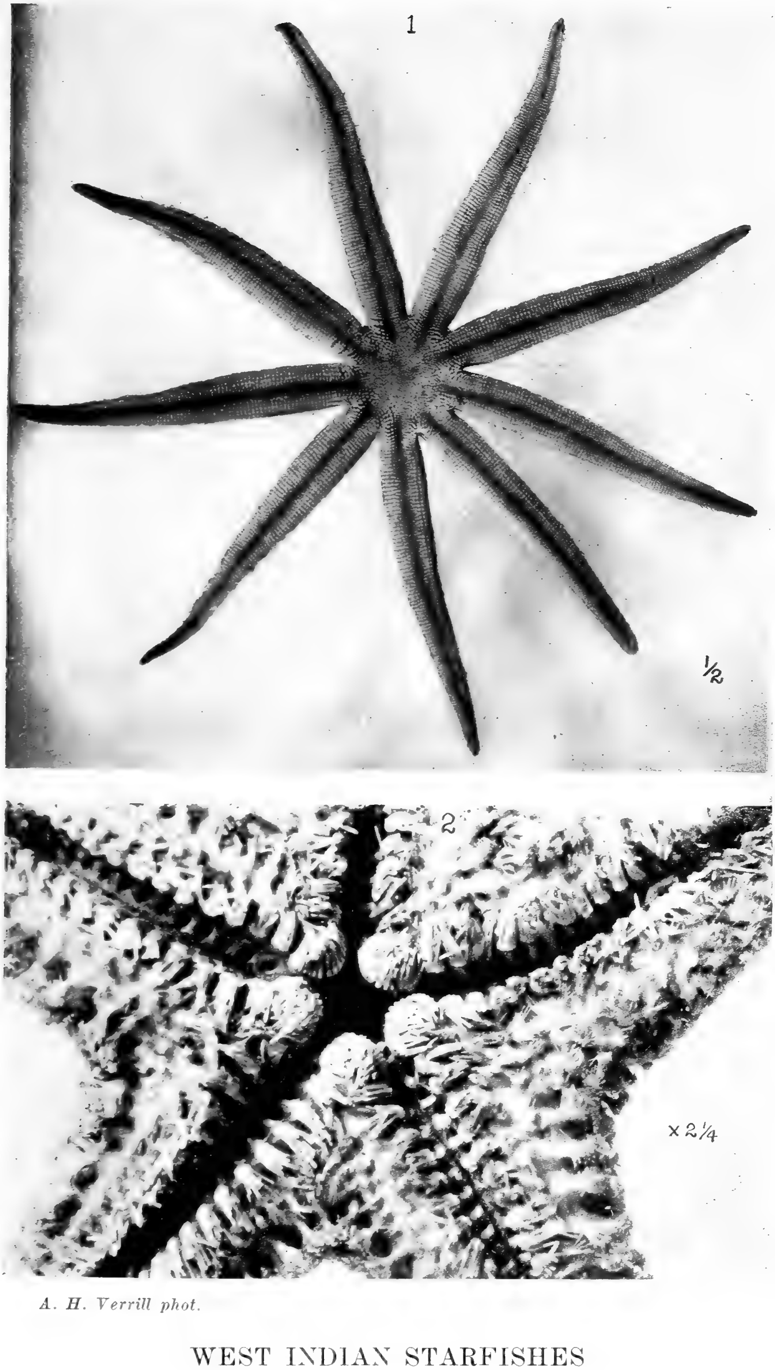
PLATE V



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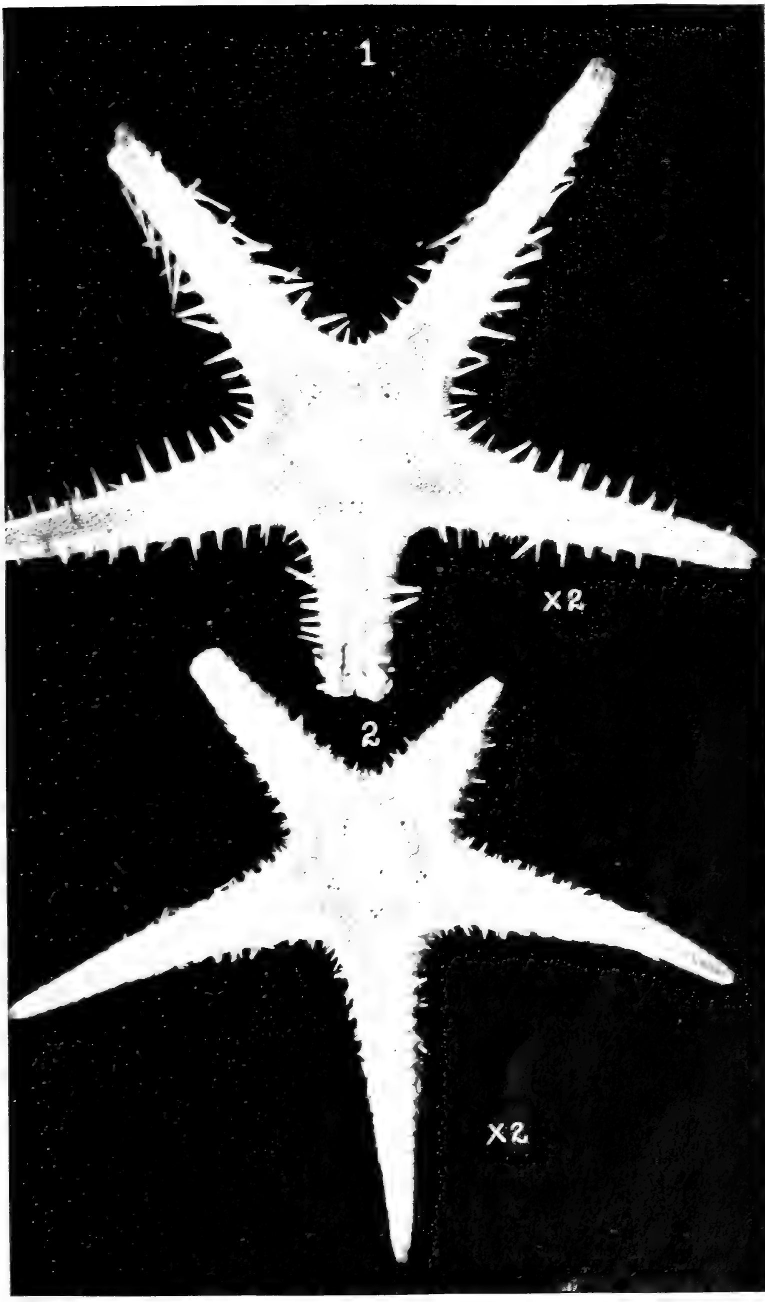

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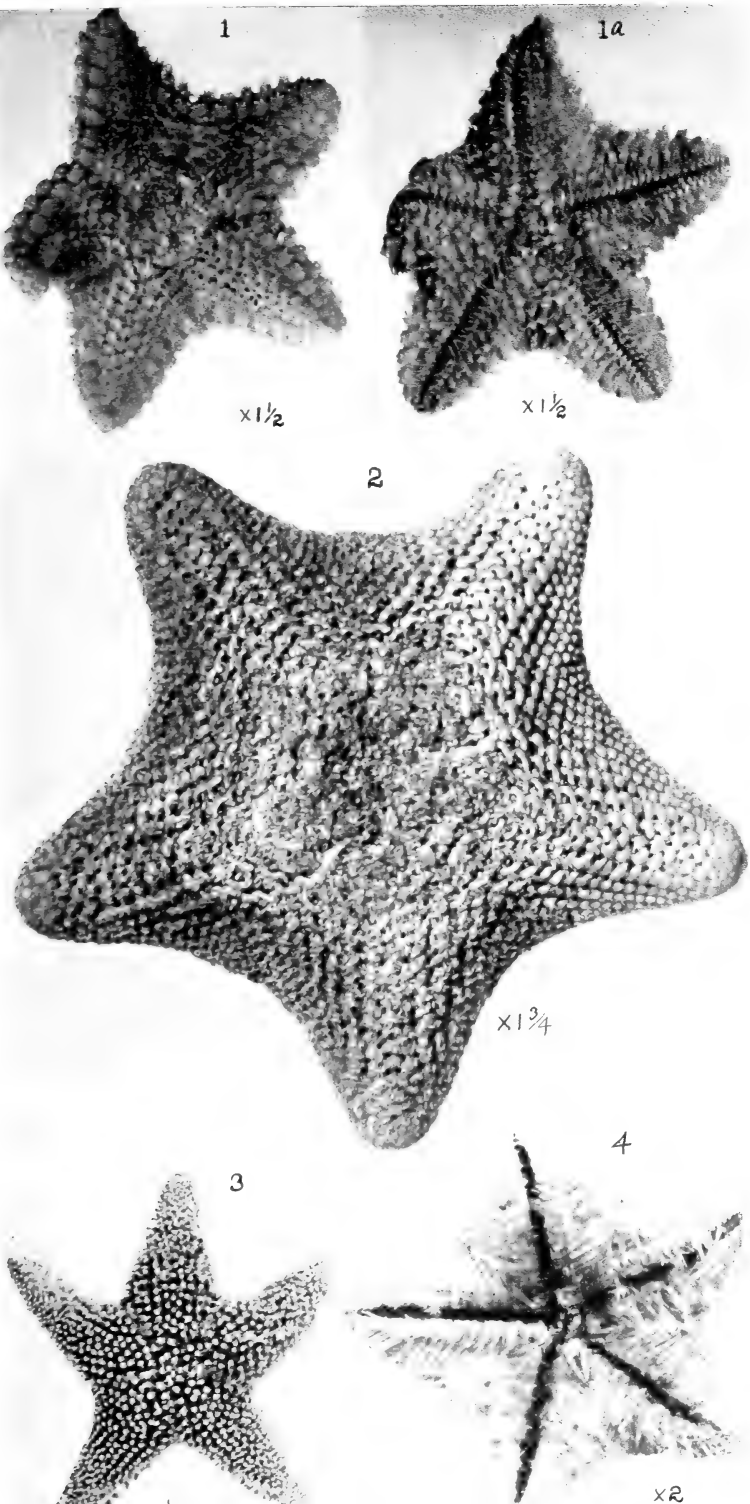

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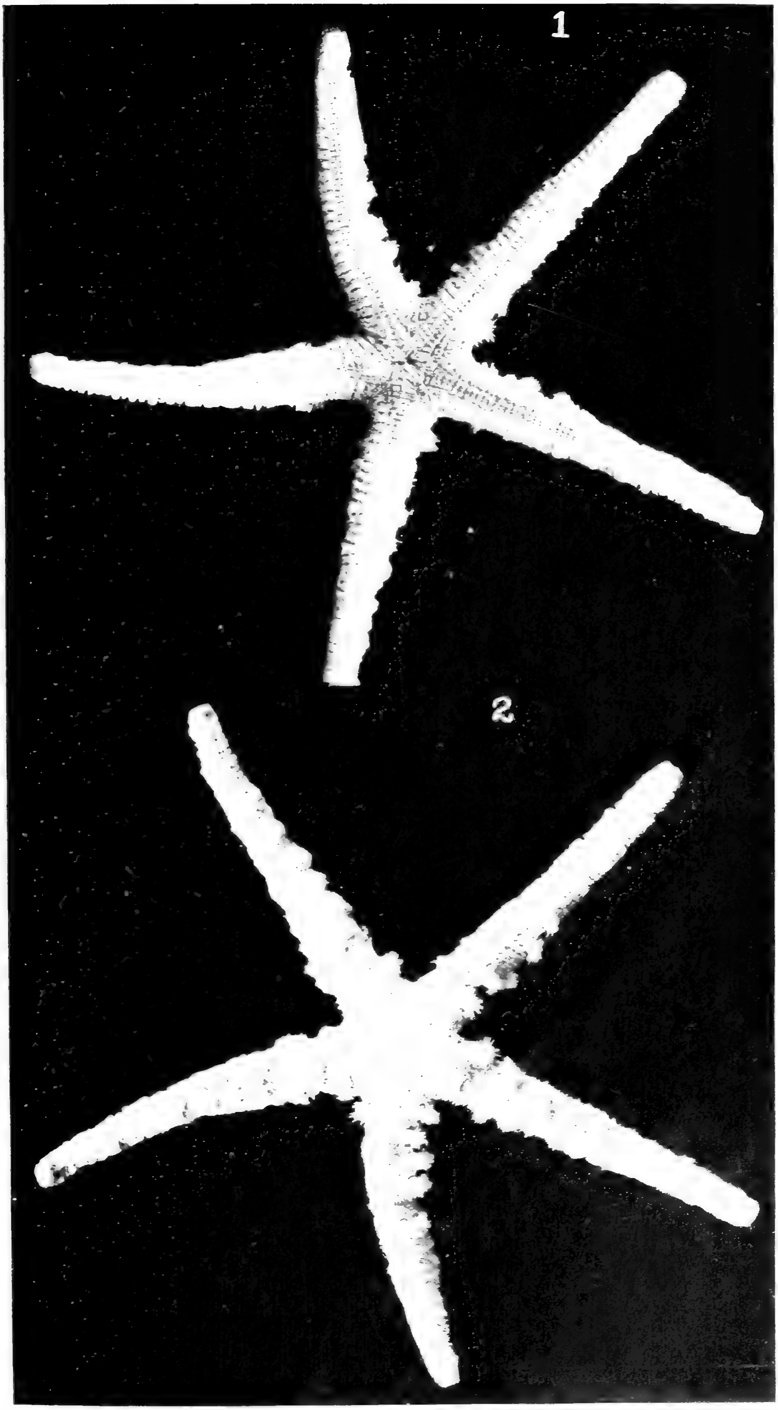

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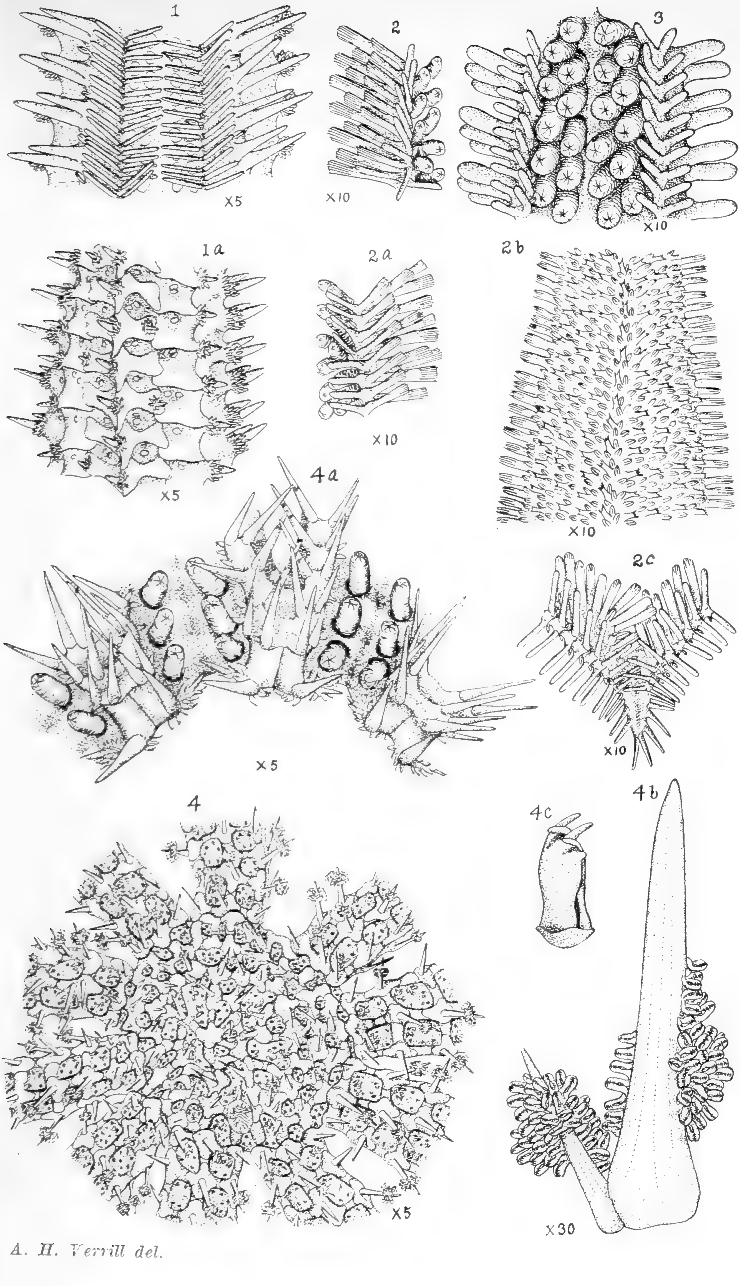

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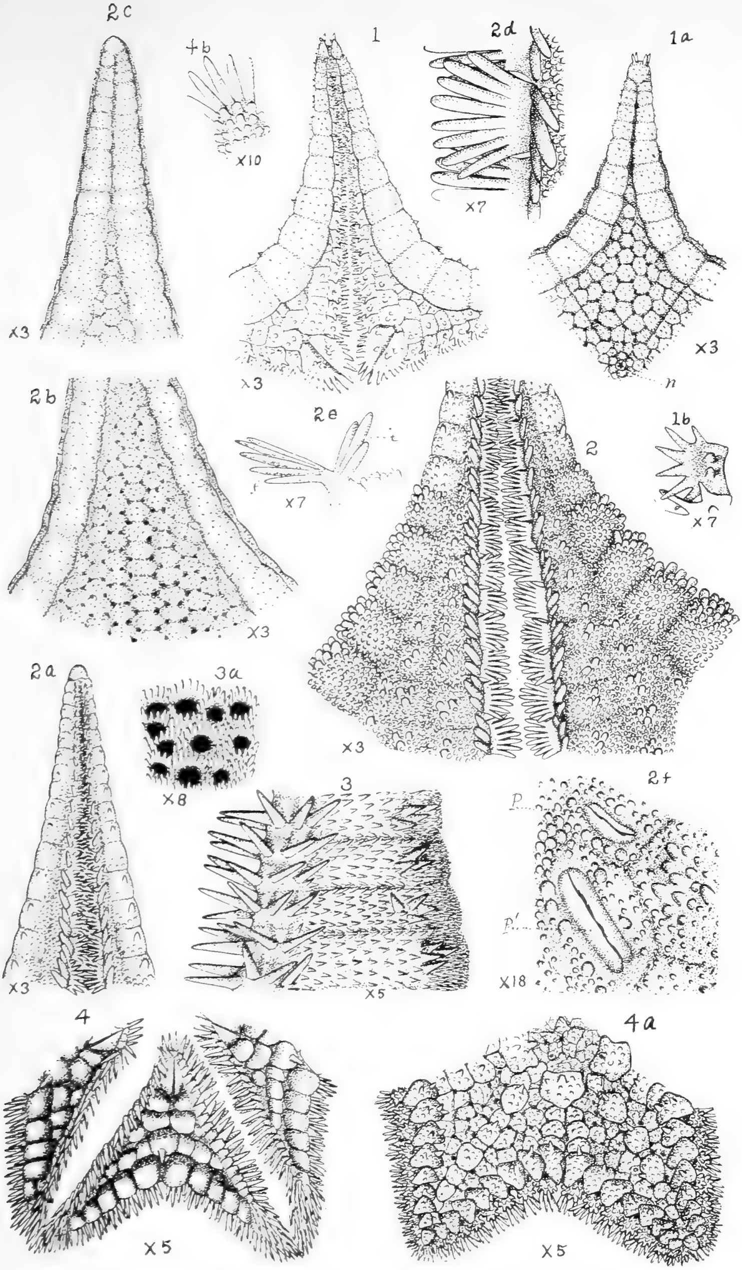

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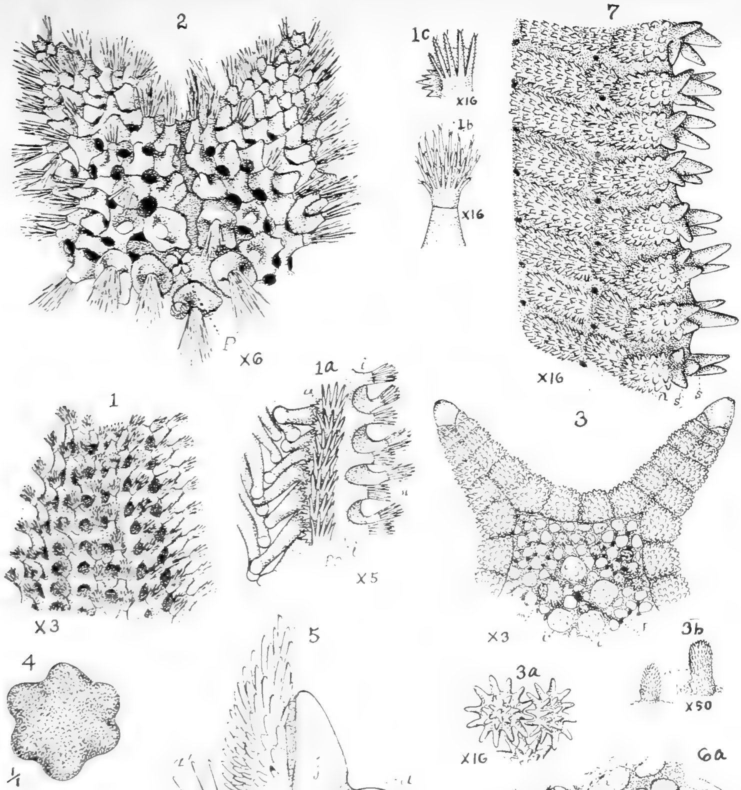
PLATE XI



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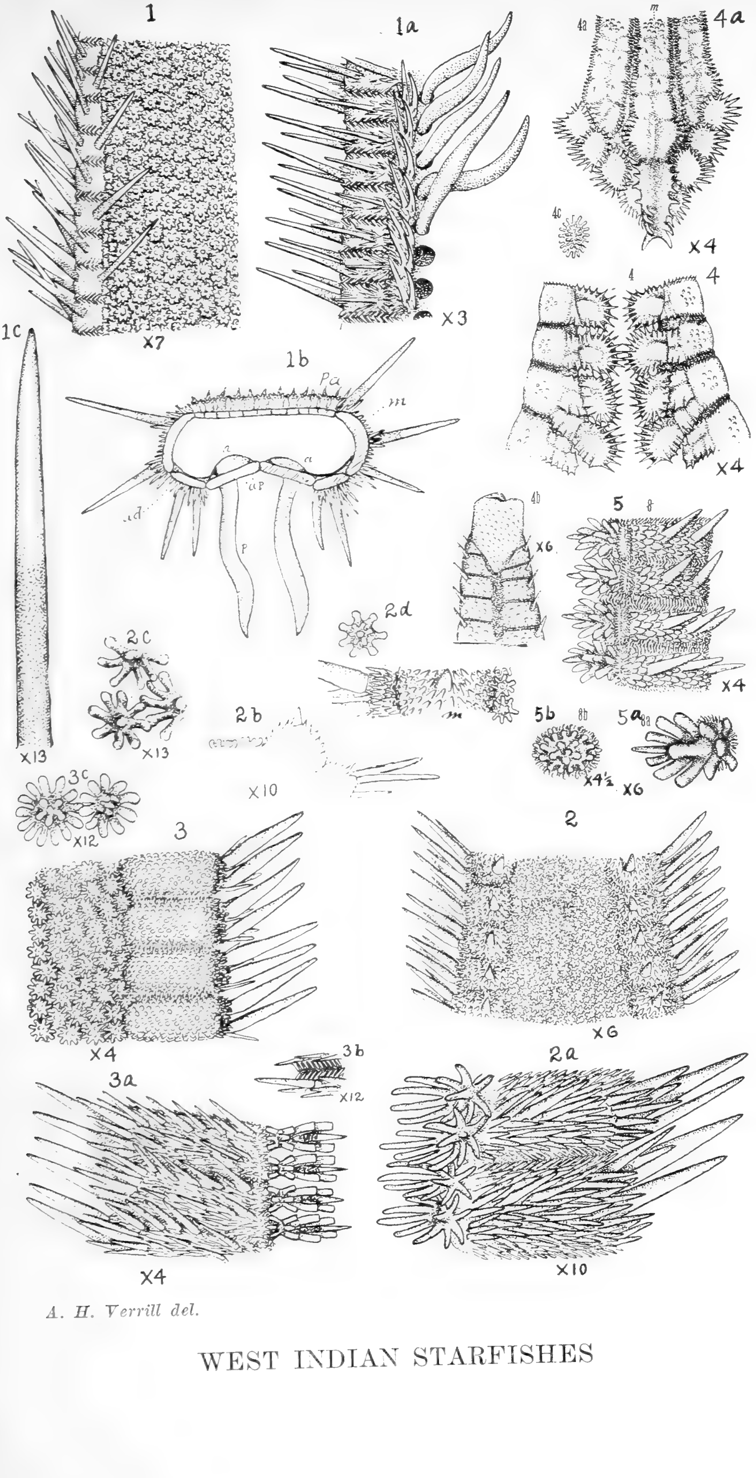

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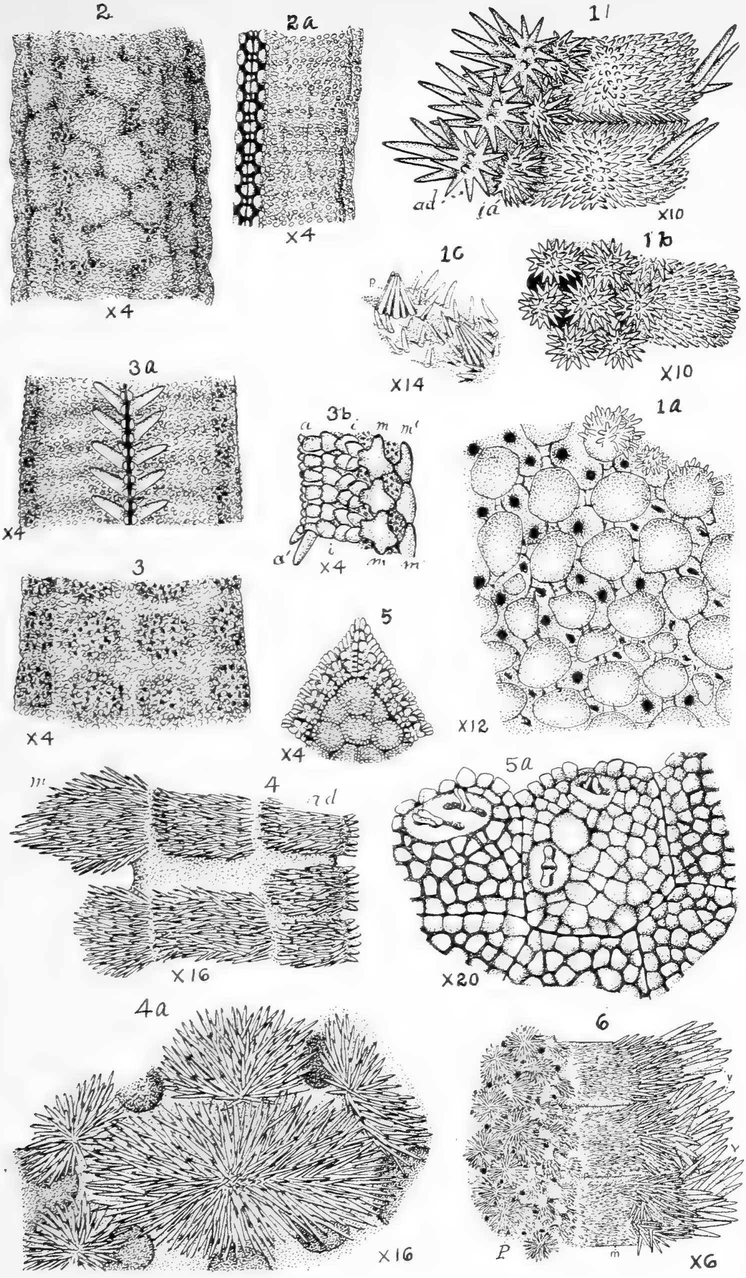

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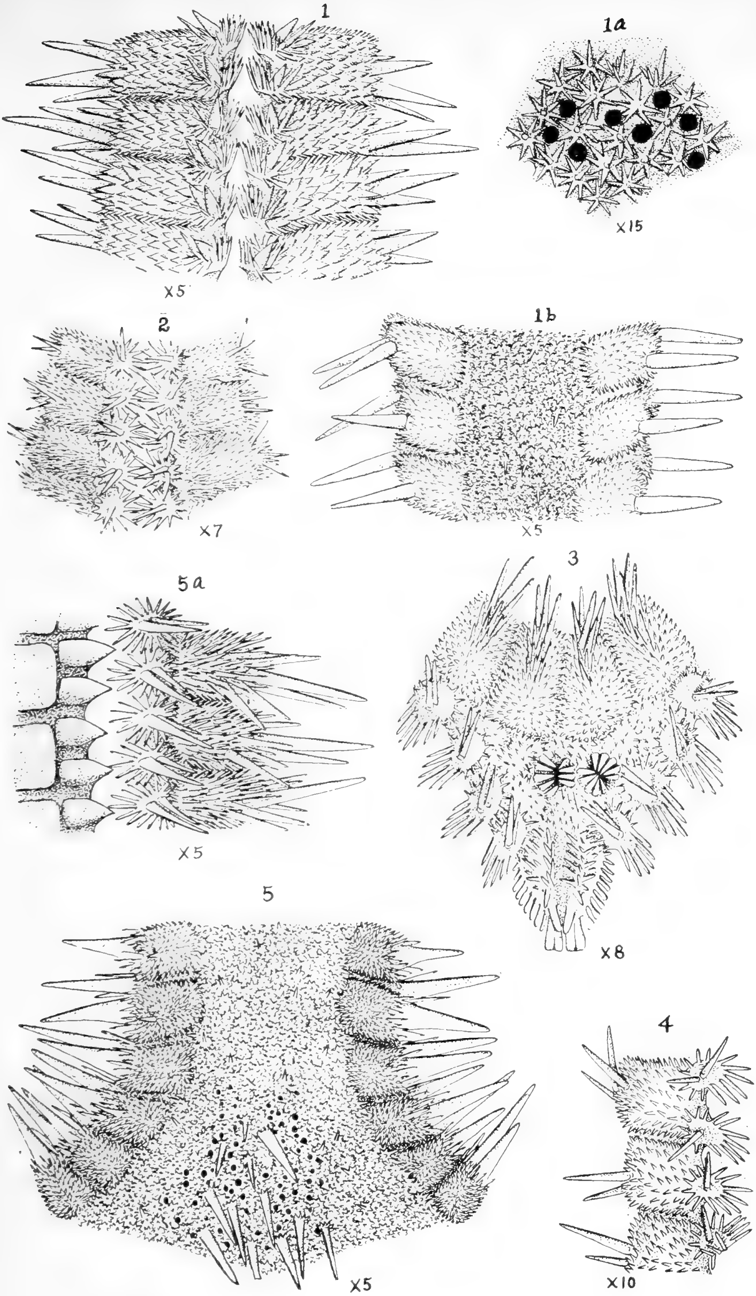

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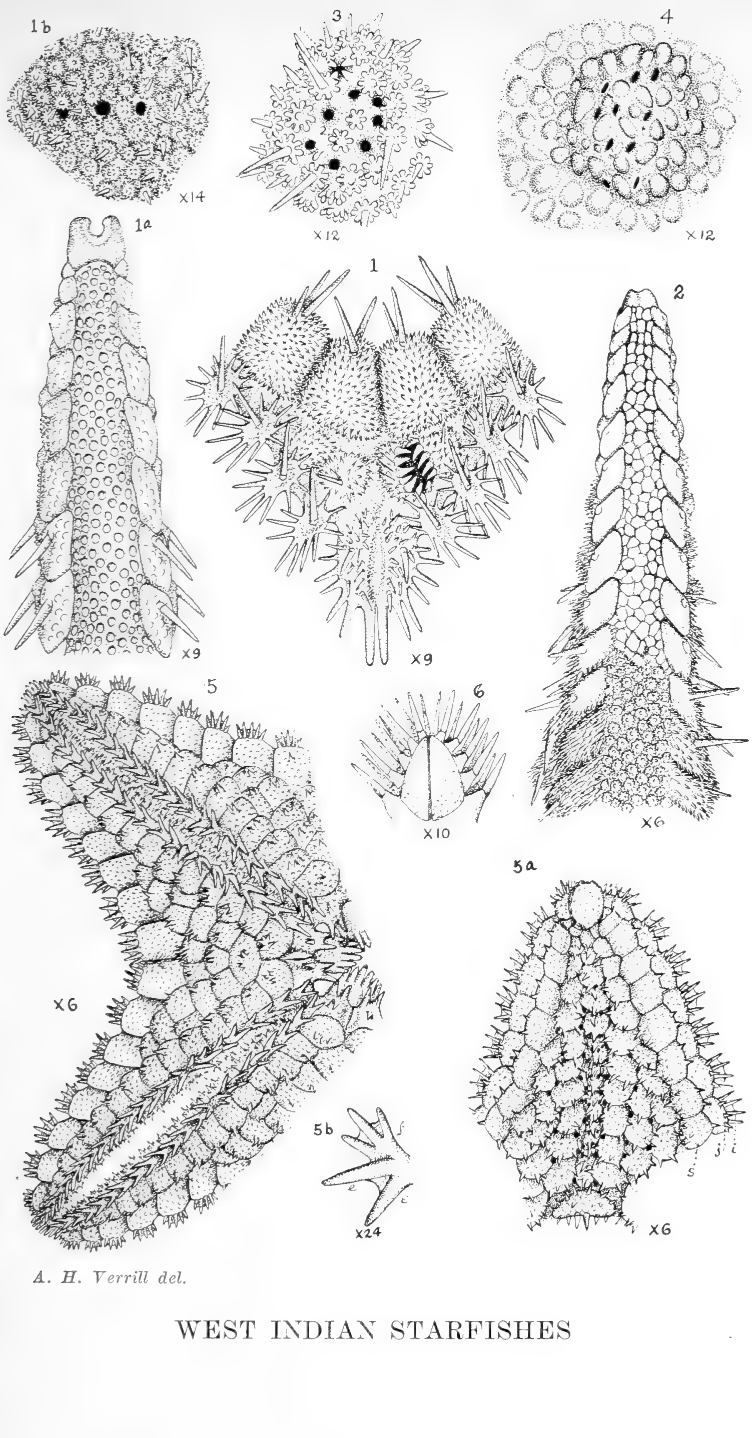

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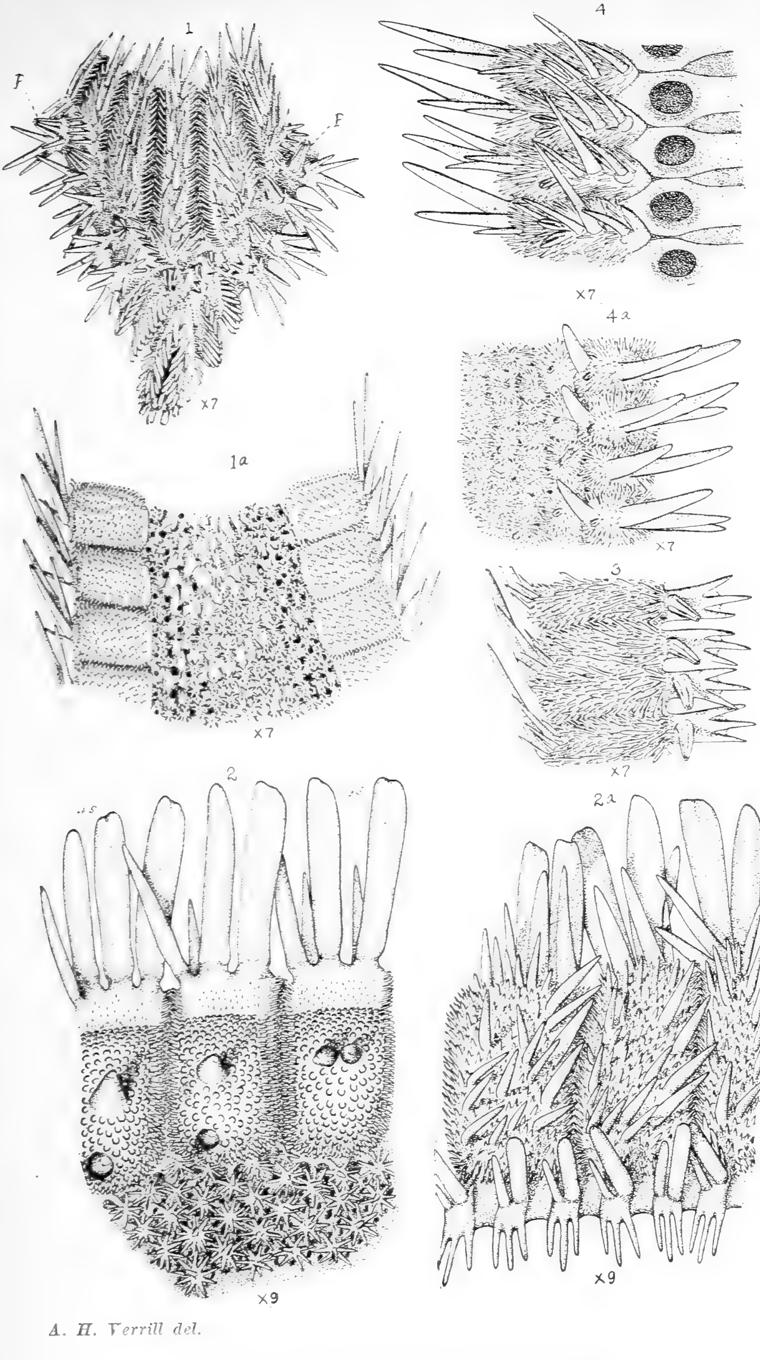

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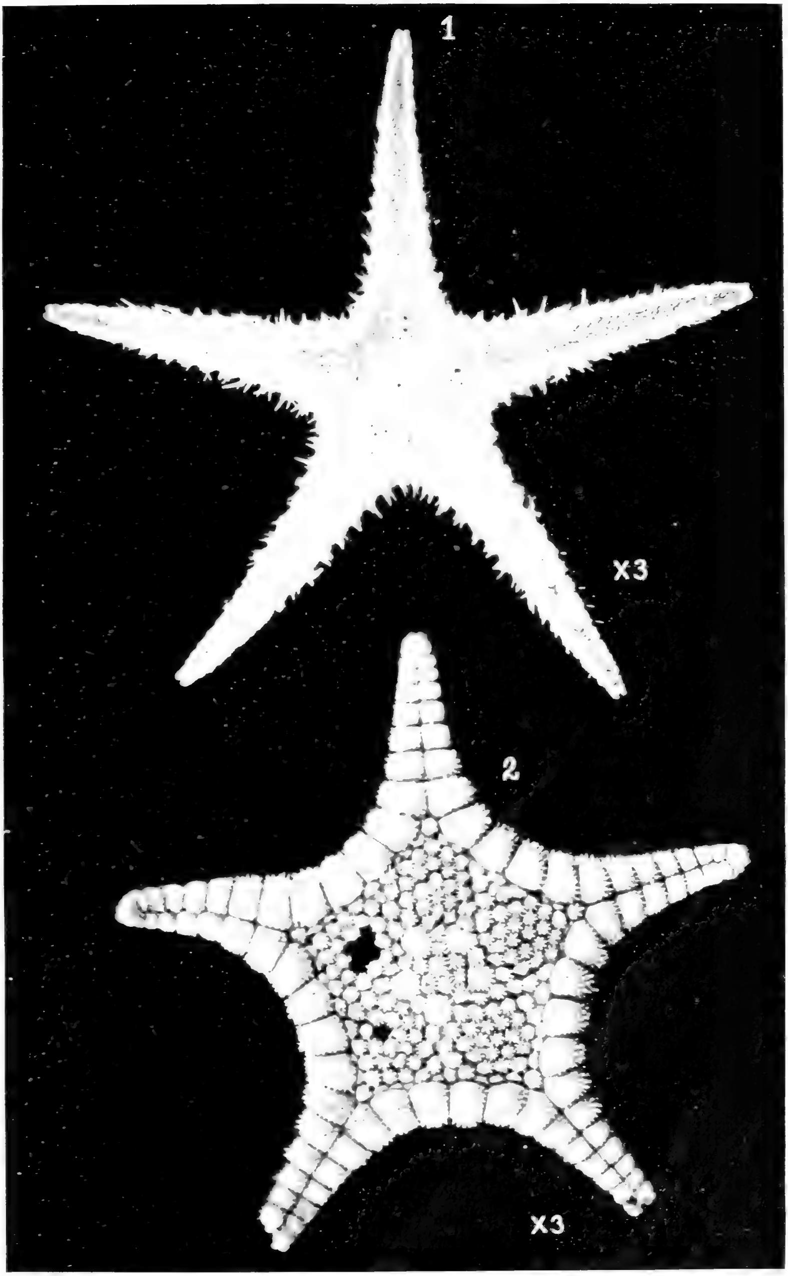

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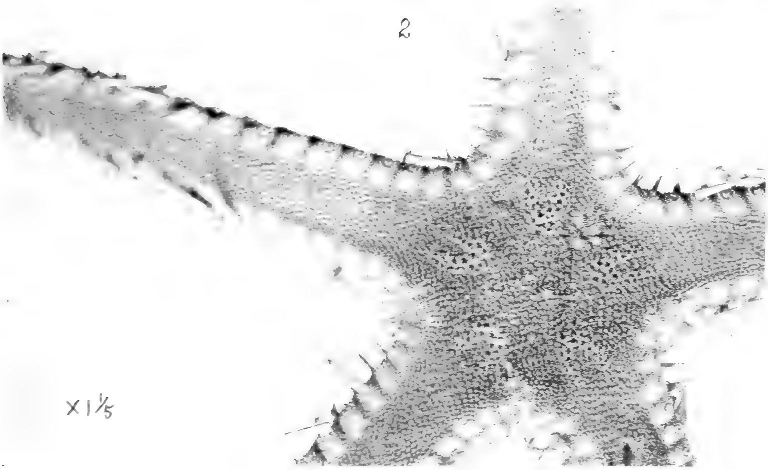

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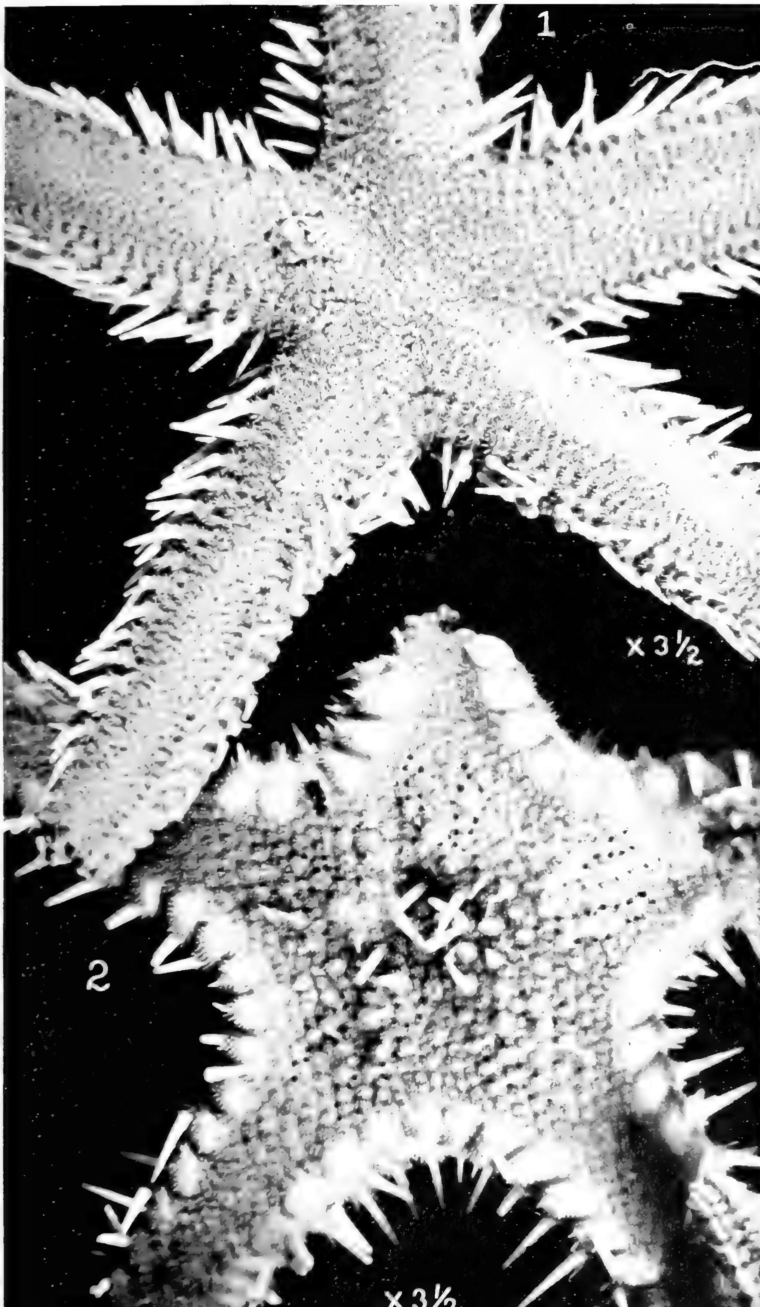

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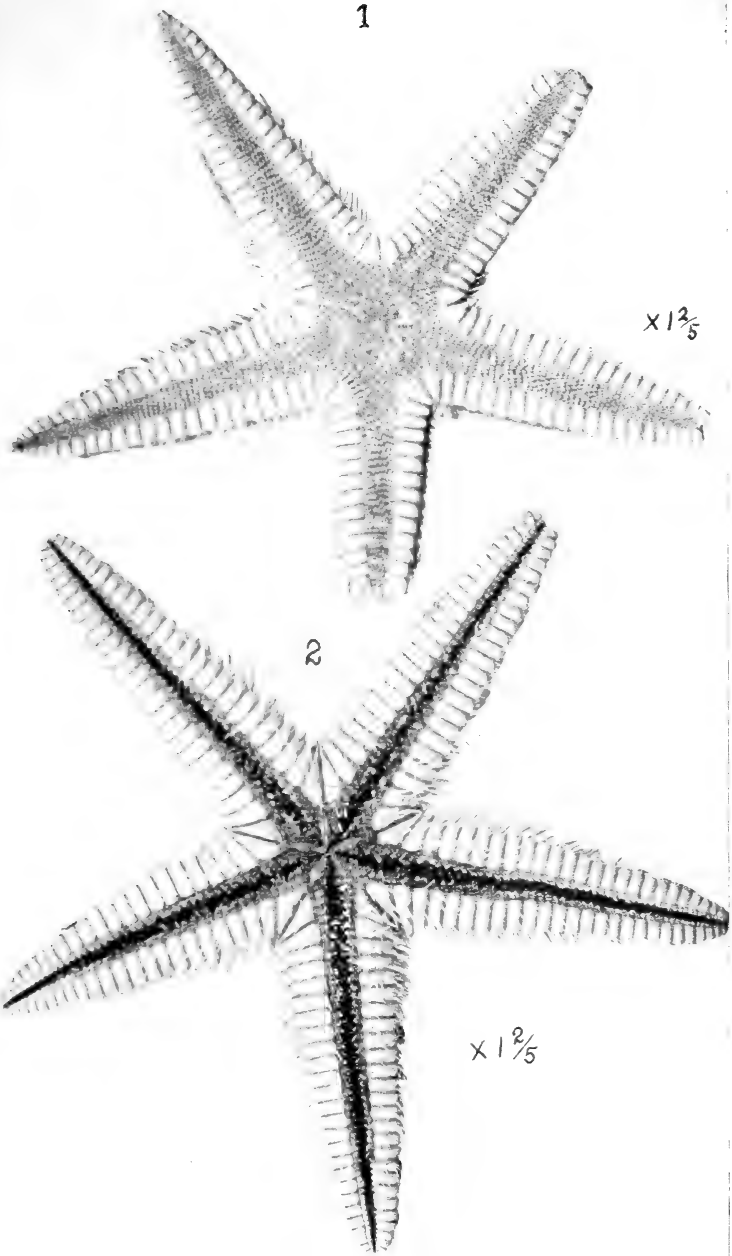

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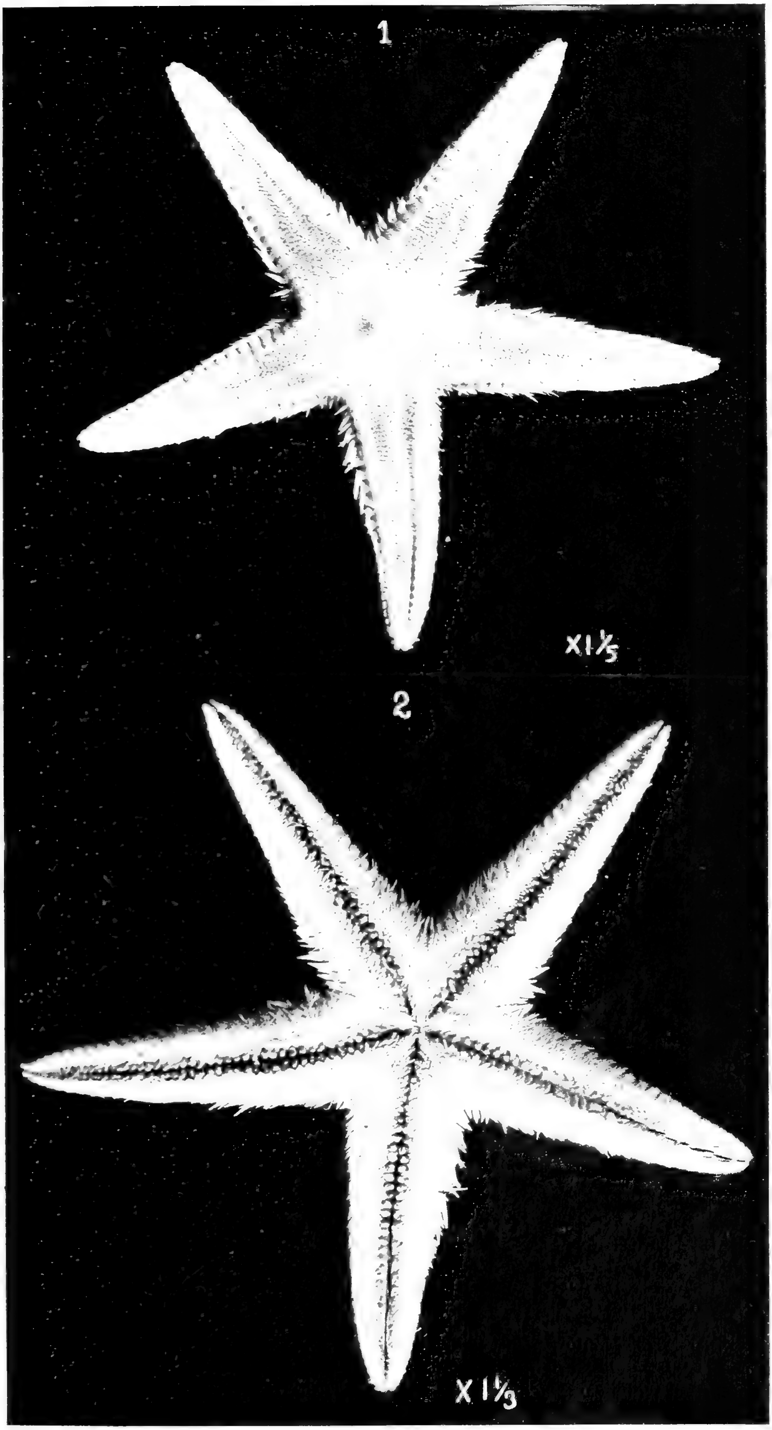

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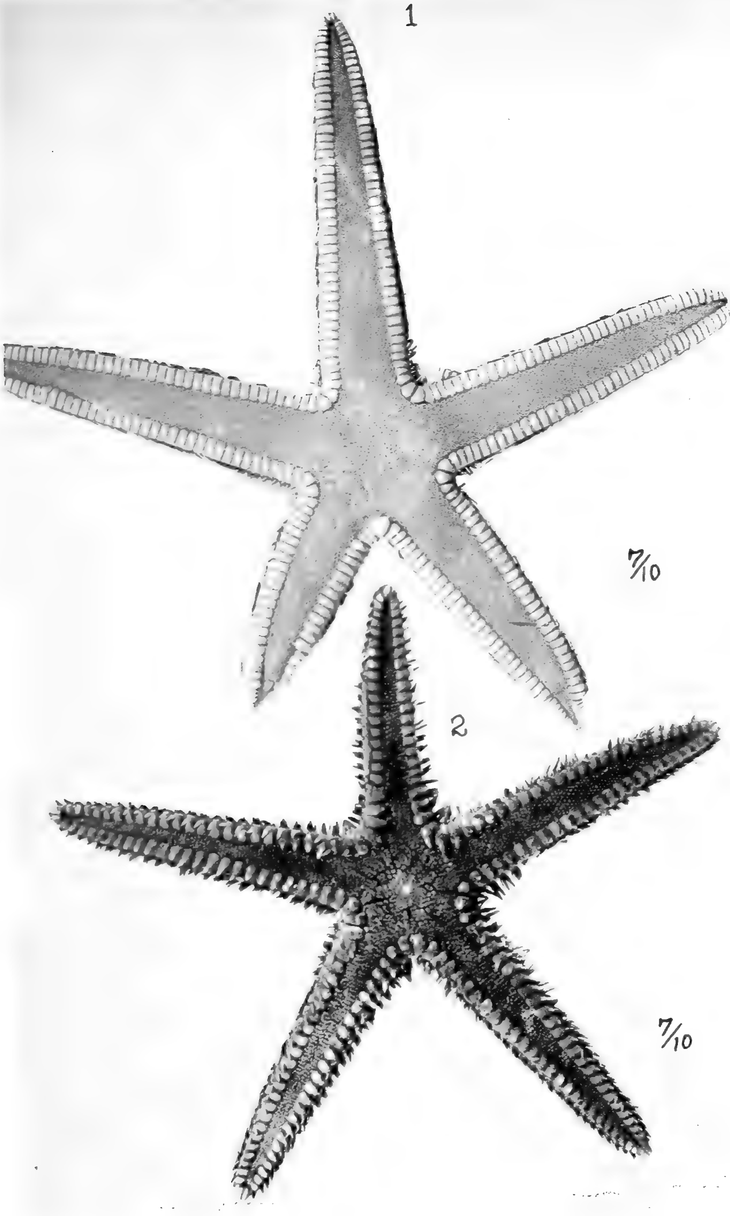

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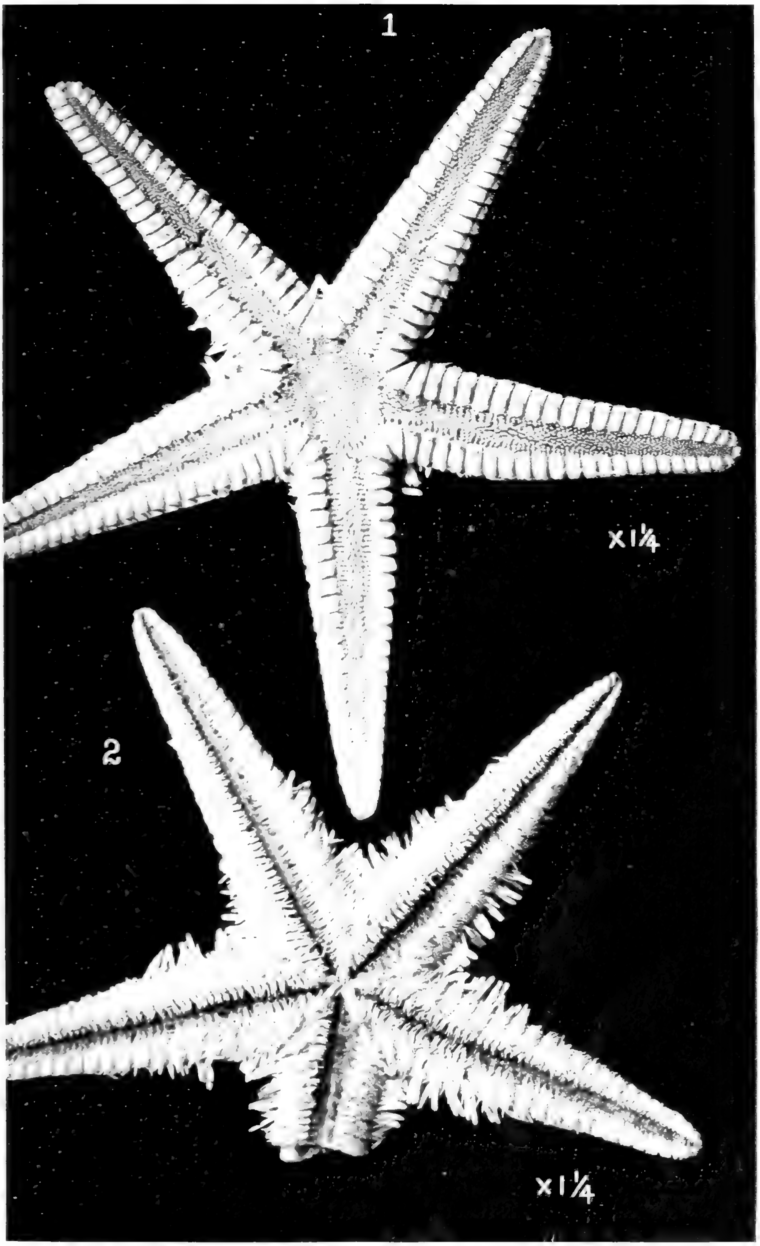

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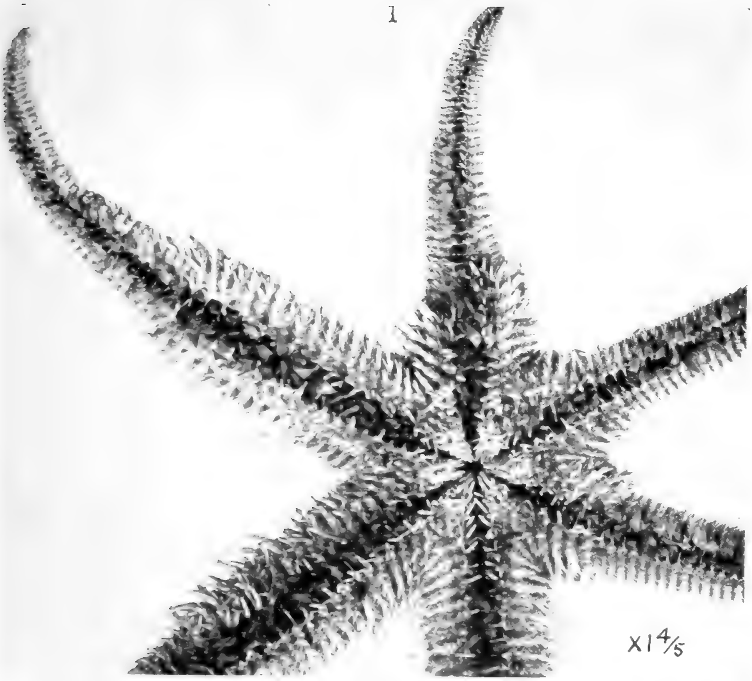

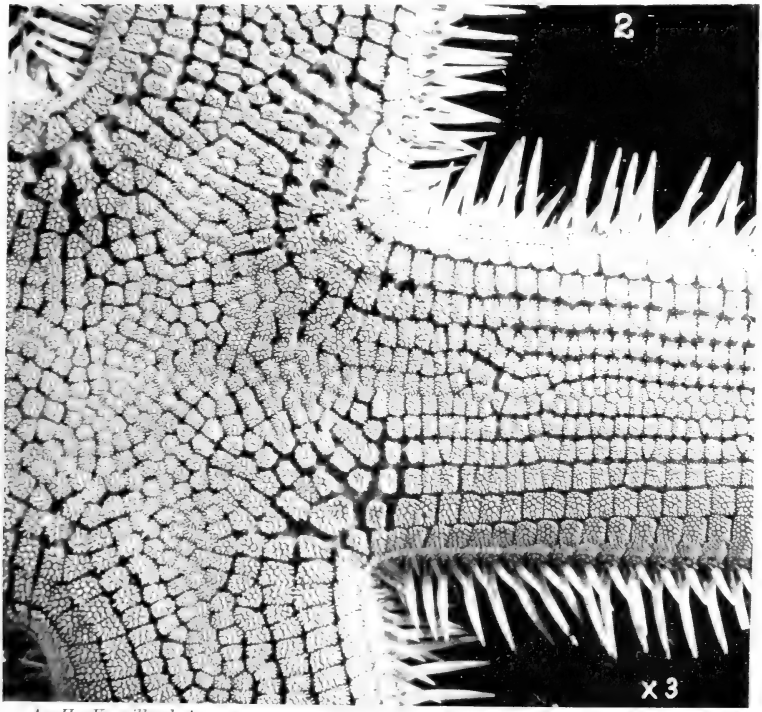

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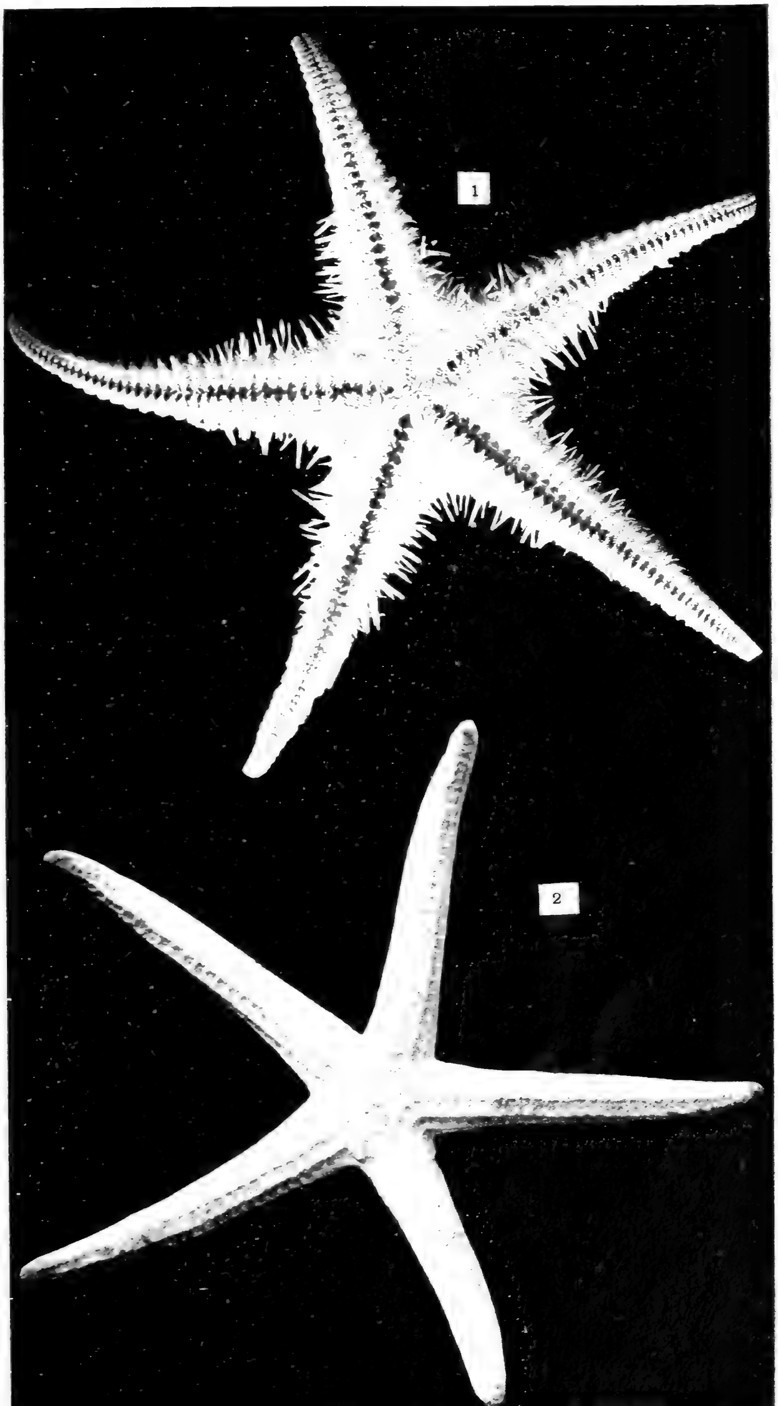

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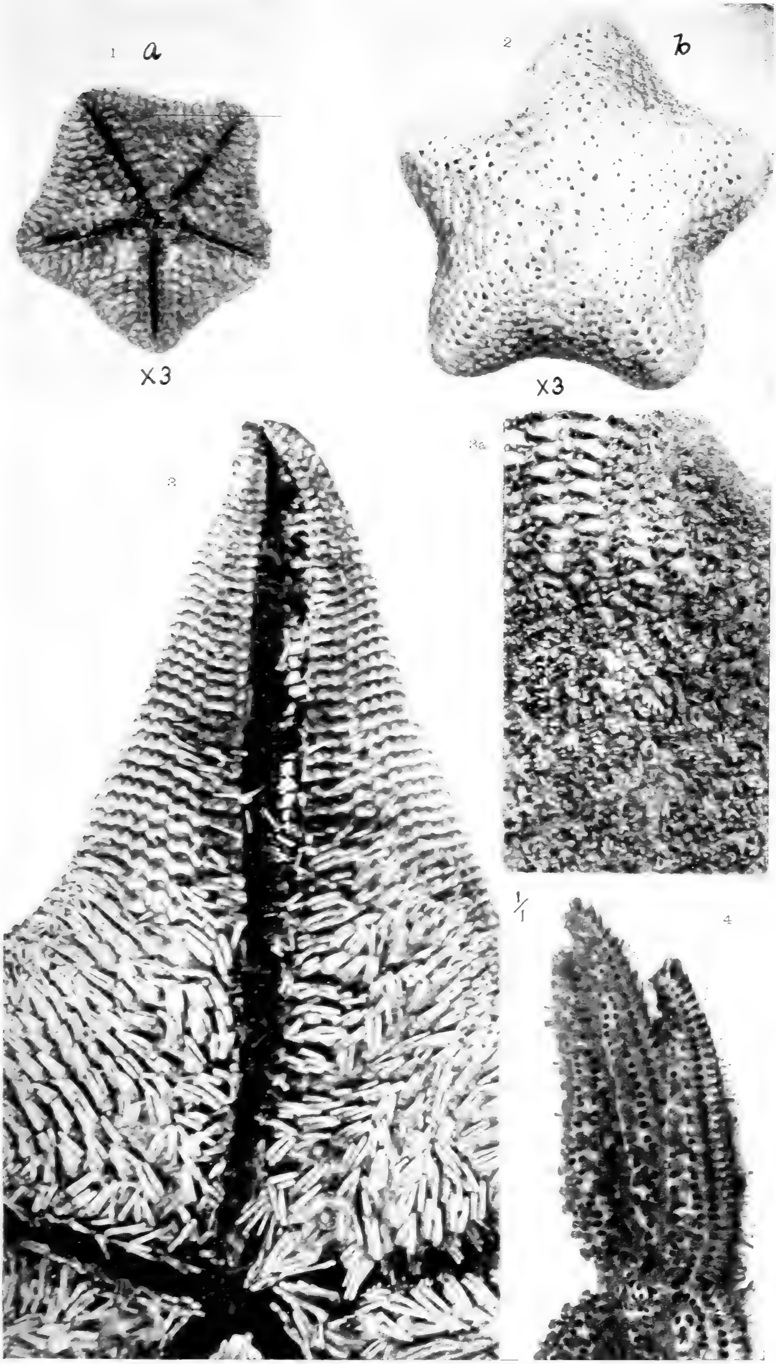

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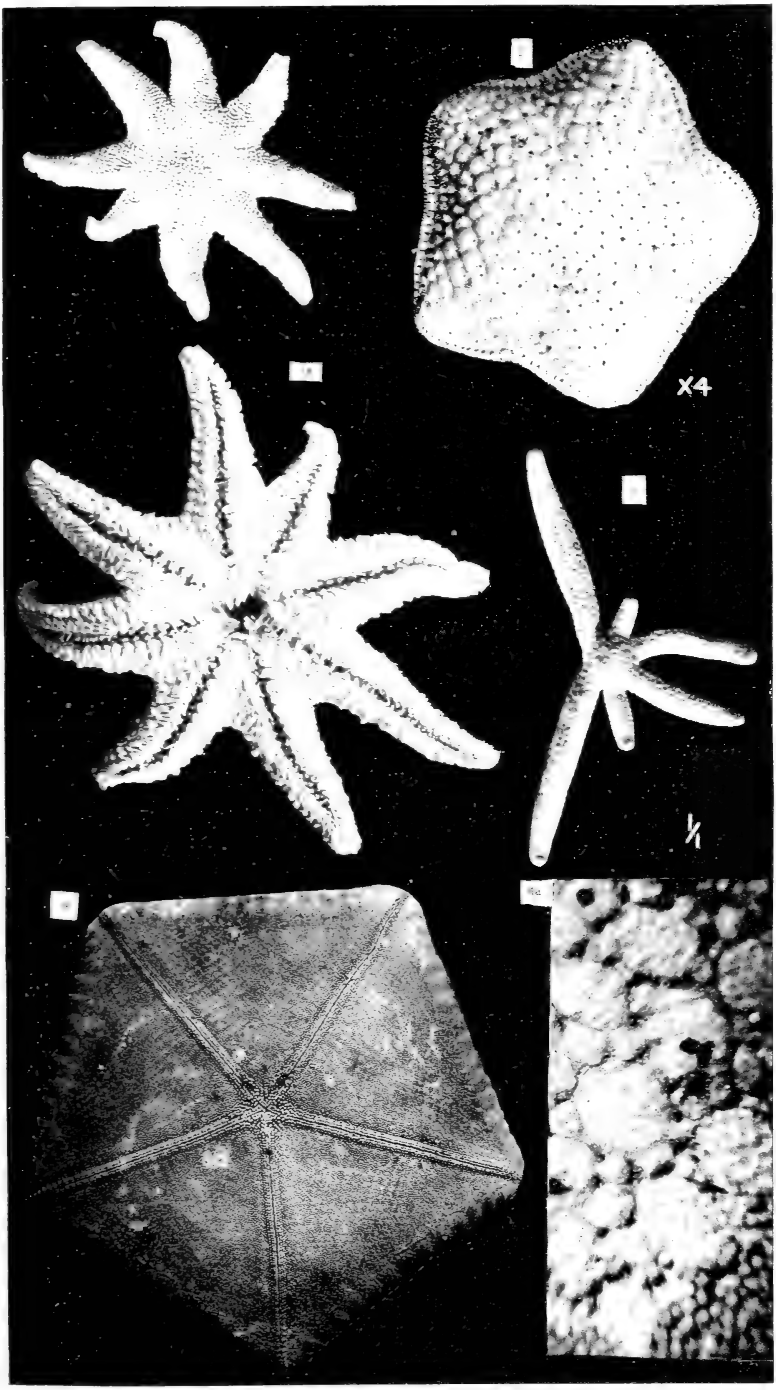

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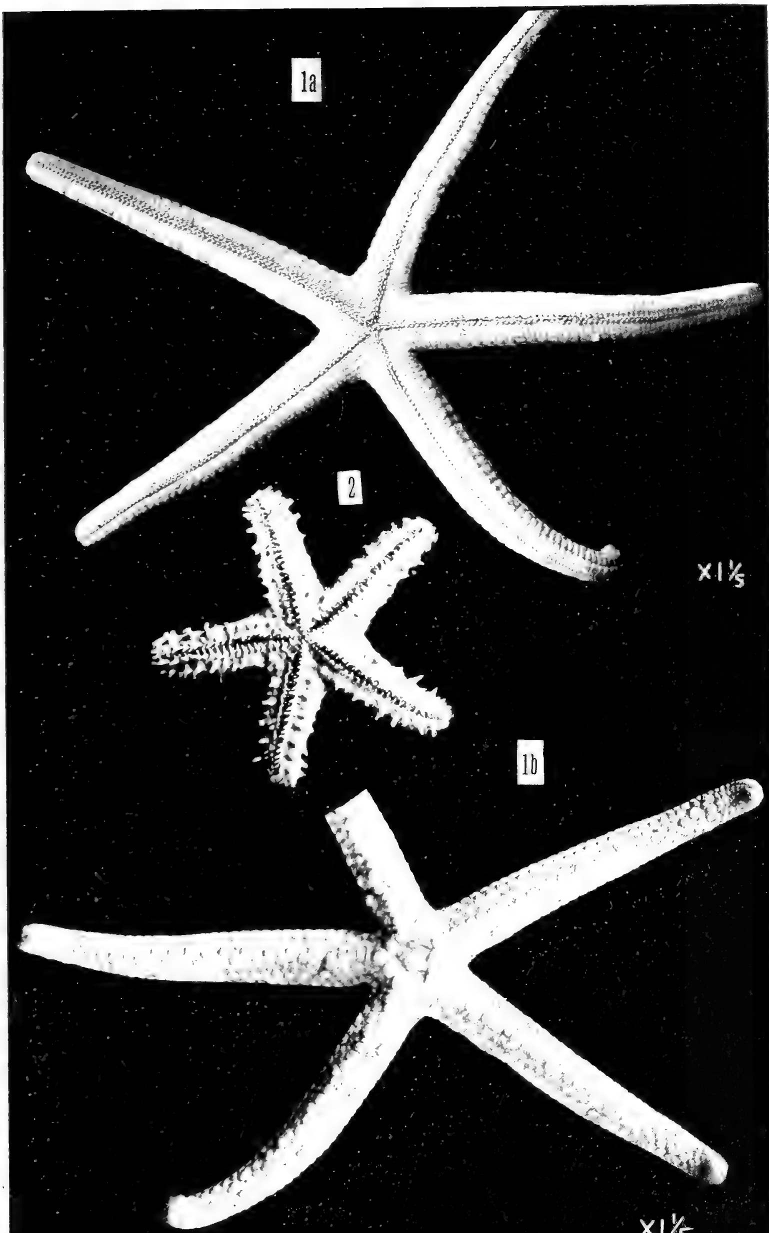

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BULLETINS FROM THE LABORATORIES
OF NATURAL HISTORY

VOLUME VII NUMBER 2

The Plant Geography of the Lake Okoboji Region

BY

BOHUMIL SHIMEK
UNIVERSITY OF IOWA

PUBLISHED BY THE UNIVERSITY, IOWA CITY

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BULLETINS FROM THE LABORATORIES OF NATURAL HISTORY

VOLUME VII NUMBER 2

CONTENTS

BOHUMIL SHIMEK
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PUBLISHED BY THE UNIVERSITY
IOWA CITY, IOWA

THE PLANT GEOGRAPHY OF THE LAKE OKOBOJI REGION

The present paper is based on observations made in the region of Okoboji and Spirit lakes in northwestern Iowa. The greater part of the work was done by the writer and his assistants during the years since the establishment of the Macbride Lakeside Laboratory in 1909, but the earliest part of it dates from the year 1894, when, during a very low stage of the water in the lakes, a very satisfactory study of the aquatic flora, flowering and fruiting in unusual abundance, was made by the writer. During the following years, and previous to the establishment of the laboratory, repeated visits were made to the region under discussion, the most extended being that of the summer of 1901, when a summer session, with eighteen volunteer students of botany, was held near the station Okoboji, between East and West Okoboji lakes, as a test of the desirability of the region for the location of a permanent biological station.

It is the purpose of this paper to present to students of the laboratory a general discussion of the flora of the region in its relation to physical environment, as a basis for more extended research in special lines, and also to set before botanists a picture of a region which shows an unusual combination of floral features.

PREVIOUS WORK

The first recorded botanical work was done in this region by the Nicollet expedition in 1839. The report of the expedition [1] includes a crude map of the lake region, in which Okoboji lakes are proportionately small, widely separated, with the west lake extending almost due east and west, and the Okoboji river emptying into its western extremity!

[1] J. N. Nicollet. Report intended to illustrate a Map of the Hydrographic Basin of the Upper Mississippi River. (Senate) 26th Congress, 2d Session. Published in 1843.

Appendix B in the Nicollet report contains a list of plants collected by Charles Geyer of the expedition, and identified by Dr. John Torrey. The following species are specifically reported from Spirit Lake: *Evonymus atropurpureus, Dalea alopecuroides, Desmanthus illinoensis* (as *Darlingtonia brachyloba* var. *glandulosa* T. & G.), *Aster novibelgii* L. and *var. minor* T. & G. (not now recognized in the region), *Xanthium echinatum, Artemisia biennis, Solanum nigrum, Physalis viscosa* (probably *pruinosa*), *Euphorbia heterophylla* (as *cyatophora Willd.*), *Panicum virgatum*, and *Sporobolus cryptandrus* (as *Agrostis cryptandra*). Other plants which are common in the vicinity of the lakes are reported from the region "between the Missouri and Mississippi rivers," and some of them may have come from our territory.

In that report Spirit lake is called "Mini-wakan" (Sioux for "spirit-water"), the Little Sioux river is called the "Inyanyanke," and Ocheydan, lying west of our territory, but of interest to students of the Laboratory, appears as "Otcheyedan," or "the spot where they cry," the mound of that name being an ancient burial ground.

Subsequently, but previously to the establishment of the Laboratory, Professor J. C. Arthur, Mr. R. I. Cratty, Professor Thomas H. Macbride, Mr. P. C. Myers, and, as noted, the present writer, worked in this region and their published reports are included in the bibliography. The region has also been visited by Professor L. H. Pammel, and perhaps others whose work is not definitely known to the writer. Since the Laboratory has been in operation other students of plants have been attracted to it, among them Professor R. B. Wylie, and several graduate students, among whom Messrs. Knupp, Giddings, Farr and Boot have published reports, as noted in the bibliography, and others will appear in the near future.

The surface features of the region have been described by several observers, among whom Nicollet, White and Macbride have been consulted. (See bibliography.)

PHYSIOGRAPHY AND DRAINAGE

This is in fact the finest lake region in Iowa, and indeed in a large part of the Northwest. The greater part of the territory

included in the accompanying map lies within the border of the Wisconsin drift sheet, which here presents a more or less broken or undulating surface the depressions of which are occupied by numerous lakes, ponds, and swamps. As may be observed by consulting the map, it contains three large lakes, namely West Okoboji, East Okoboji, and Spirit lakes, and a large number of smaller bodies of water ranging in size from Center lake, which is a very considerable body of water, to small "kettle-holes," such as are especially abundant between Center lake and West Okoboji lakes, and west of the latter lake.

Spirit lake is the largest of the lakes in superficial area, but it is comparatively shallow, its greatest depth probably scarcely reaching 40 feet. Its comparatively regular outline presents few bays and coves, in the shelter of which many aquatic plants thrive best, and this coupled with the prevailing sandy or gravelly shores and bottom, and the greater exposure of the surface to storms, probably accounts for the lesser variety and abundance of aquatic plants in this lake. The northeastern part of the lake is probably the richest in flora, and here beds of rushes and other aquatic plants are locally well-developed.

The northern and northeastern shores of the lake are low, with sandy or mud beaches, and outlying pools and swamps which are usually crowded with plants. The south shore of the northeast bay is bowldery. The banks of the southeastern shore are abrupt, and in some places rise to a height of 20 feet. The southern shore is a rather flat, bowldery and sandy beach (see Plate VI, fig. 2), which is continued southward as a flat sandy prairie to meet the north beach of East Okoboji lake. The entire western shore is bordered by more or less interrupted abrupt banks which reach a height of 10 to 25 feet, and at one point north of Templar Point, fully 30 feet above the lake. Occasionally a low draw, forming a swamp or pond, appears as an outlier, or connects with the lake, as west of Templar Point and in other localities northward. Northwestward the territory bordering the lake becomes rougher, and its depressions are occupied by a series of smaller lakes of great interest. These lakes are all shallow, and as the summer advances, and during dry seasons, broad, sandy, or more frequently muddy flats are exposed. These fluctuations in level check the development of many plants along the shores, but in the somewhat deeper, more permanent

parts of the lakes vegetation is very abundant. Large beds of rushes (*Scirpus validus* Vahl.) appear in Marble, and especially in Robinson (or Kettleson) lakes, chiefly on the southern and western sides, nearer the flat, treeless shores. Here, as elsewhere, these rush-beds seem to mark the location of low bowldery or gravelly ridges or areas. Most of the beaches of these lakes are soft and very muddy, but the eastern shore of Marble lake is largely sandy. A ridge nearly 50 feet in height separates Marble and Robinson lakes, and extends between Marble and Hottes lakes, where it drops to about 35 feet. This ridge is flat, with abrupt slopes or banks, and is interrupted by sags which connect the three lakes during high water. A low place on the northeastern side of Marble lake provides an outlet into Spirit lake during high water. The level of the water in these smaller lakes is approximately that of the water in Spirit lake. That part of Little Spirit lake, another member of this group, which lies in Iowa, is also shallow, and usually overgrown with aquatic vegetation. It connects with Spirit lake across the narrow "causeway" near the center of section 8. A prominent wooded ridge extends between its two lobes but the southern and western shores of the west lobe are low and treeless. The great swamp or bay which extends northward into Minnesota from Crandall's Lodge is also rich in vegetation.

Several smaller bodies of water are found in the Hottes lake region, the most interesting being Sunken lake which lies between Hottes and Marble lakes. This is a small lake which has been comparatively recently formed, according to tradition. It is completely enclosed by high, abrupt banks excepting for a narrow connection with Hottes lake, and is surrounded by forest. The rougher part of this section is heavily wooded and the region presents a variety of forest, prairie, swamp and lake conditions of great interest to the botanist and zoologist.

Excepting in the Hottes lake region there is but little timber bordering Spirit lake. It is a striking fact that the forest fringe is found only where there are abrupt, high banks. In such places the banks are usually bowldery. The flat shores, usually sandy or muddy, which gradually rise to the prairies beyond are treeless. The shaded areas on the map represent the forest, and also, therefore, mark the location of the higher banks and rougher surfaces.

The outlying region to the east, north and west of the lake is rolling prairie, with higher knobs visible in the northwest.

East Okoboji lake is a narrow, irregular shallow body of water. Throughout its northern two-thirds the depth scarcely reaches 6 feet, and during dry seasons becomes much less. In 1896, and again in 1902, it was almost impossible to row a boat in any portion of this part of the lake on account of the shallowness of the water and the abundance of vegetation (see Plate VII, figs. 2 and 3). The southwestern portion of the lake reaches a depth of about 25 feet. The northern end of the lake is bordered by a sandy beach. Southward both shores are formed by higher banks and bluffs more or less wooded, those on the west side and below the town of Spirit Lake varying from 10 to 55 feet in height (see Plate VII, fig. 3). Where the lake turns westward abruptly the shores become flatter and the surface rises gradually to the north to an elevation of over 75 feet. That part bordering the west side of the lake in section 10 is cut by ravines, and tongues of prairie, similar to that shown in Plate I, fig. 3, follow the tops of the ridges into the wooded area. Near the railway station Okoboji the banks are again higher, and more or less forested. The east side of the lake is also bordered more or less by uplands. The east banks of the northern lobe of this lake vary from 10 to 20 feet in height, and there is a distinct border belt of forest. From the drawbridge at Spirit lake southeastward to section 11 the low bluffs are irregular, variable in height, and in places recede from the lake. In sections 11, 14 and 15 the bordering upland is more massive, the bluffs or slopes follow the lake more closely, and the whole area is heavily wooded, forming the largest forest in all the territory discussed in this paper.

West of this forest and extending to Stony Point, the shores are again lower, the slopes from the uplands more gradual, and treeless. A group of mounds extends westward from Stony Point, and here again the more abrupt, sheltered slopes and valleys are forested. Beyond these mounds another low, treeless section borders the lake. Twin Mounds, which will be further discussed, present both prairie and forested slopes (see Plate V, fig. 1). Thence to the south end of the lake the banks are quite abrupt, and in places a second line of uplands approaches close to the lake.

Along the entire shore line we again find that trees grow only on the abrupt, sheltered slopes, or on areas protected by such slopes, and that the flatter unprotected shores are treeless. The forest map thus again becomes in fact a topographic map.

The flatter beaches are mostly sandy, or muddy northward, while opposite the higher banks, marked by the forest fringe, the beaches are bowldery. Outlying or connected pools and swamps are quite frequent along all the lower shores. Bowldery reefs are usually found extending into the lake from the more abrupt points along the shore line. These often form an anchorage for interesting water plants, such as *Potamogeton*, etc.

Eastward from this lake the uplands rise to form the watershed between the Des Moines river of the Mississippi drainage and the Little Sioux river of the Missouri drainage. Southeastward there are several kettleholes, of which the largest and most interesting is *Prairie lake*, which drains into Lower Gar lake. It is a shallow lake densely crowded with water plants, especially at the northeast end. Its banks rise to a height of 10 or 15 feet, and, where abrupt, shelter small groves. A wooded ridge almost cuts off a swamp on the northwestern side. The level of Prairie lake is much higher than that of East Okoboji lake (about 80 feet?), and the ridge to the northwest, between the two lakes, near the church, is over 40 feet above the level of Prairie lake.

The Gar lakes form an interesting chain extending southward from East Okoboji lake. The Middle lake is the deepest, reaching a depth of from 10 to 20 feet. The Lower lake scarcely reaches a depth of 6 feet. As before, the more abrupt banks, with bowldery beaches, are marked by a forest fringe, while the flatter shores, often swampy, sometimes sandy, are treeless. The Upper Gar lake, and that part of Lower Gar which receives the water from the outlet of Prairie lake, contain the richest aquatic vegetation in the Gar lake group.

West Okoboji lake is by far the finest body of water in Iowa, and it, together with its immediate vicinity, furnishes to both botanist and zoologist unusual opportunities for field-work. Its irregular outline and much greater depth bring about a variety of conditions unequaled in any other lake of the state. It connects with East Okoboji lake by a narrow strait, crossed by a railway and a wagon bridge, and the shallow portions of both lakes adjacent thereto offer a fine field for work. From this

point southwestward, quite to Terrace Park, the banks are mostly abrupt, and vary from 15 to 30 feet in height above the lake. A part of the beach at Arnold's Park is flat and sandy, but most of the shore, especially from Pillsbury's Point to Terrace Park, is quite bowldery. The beach at Terrace Park is flat and sandy, and gradually passes into the upland prairie to the south. Both shores leading to Pocahontas Point are bowldery with abrupt banks, a low wooded ridge extending almost to the point. West of Pocahontas Point the lake connects, during high water, with a long slough or draw which extends southward.[2] It is shallow, usually crowded with plants, and a narrow fringe of trees has developed in the shelter of its more abrupt eastern banks. The beach on the west side of Emerson's Bay is sandy with occasional bowlder-covered sections where higher banks appear. The forest fringe is very narrow and interrupted. One of the most interesting sections of this territory lies between Emerson's and Miller's bays. It consists of a series of low, well-wooded ridges separated by treeless swamps and sloughs. It is cut off from the prairie upland to the west by a great swamp, extending from bay to bay, which narrows southward and is there bordered by bur oak groves on the more abrupt sheltered slopes, which rise 15 to 25 feet above the lake. A few small groves are found in similar situations on the west side of the swamp south of the section line. Some of these groves, and a part of the swamp are shown in Plate VII, fig. 1. This swamp has been recently cut by the Beck canal which connects the two bays, and also cuts the swamp along the southern border of this large peninsula.

Fine sandy beaches border the lake west of Bluff Point, on both sides of Gull Point and around the Cove just south of Elm Crest. The northern shores of the peninsula (shown in Plate II, fig. 3), the greater part of the shore lying between Elm Crest and Gull Point, and that in the immediate vicinity of Bluff Point and the point west of it, are bordered by wooded higher banks or low bluffs, with bowldery beaches. In the vicinity of the Cove these banks are 15 to 20 feet high. Swamps everywhere border the lower shores and penetrate far into the wooded uplands of the peninsula.

That part of the shore lying between the sandy beach immediately north of the outlet of the canal and the Laboratory is

2 Known as Green Slough.

also abrupt and rises up to 25 or more feet above the lake. This also is wooded (see Plate II, fig. 1, and Plate VI, fig. 1). The abrupt beach on the Laboratory grounds is covered with bowlders, but flatter sandy beaches are found immediately southward along the west side of the bay, and northeastward to the long spit which extends out from the northern shore of the bay at low water. The former are shown in Plate VI, fig. 1, and the latter in Plate VIII, fig. 3.

Northward from the Laboratory the banks and bluffs vary in height, much as along the western shore of Spirit lake. Wherever groves are represented on the map the shores are higher and more abrupt, and the beaches are bordered or covered with bowlders; where the shores are treeless they are lower, sandy, or rarely muddy, and the surface slopes upward gradually to the more remote prairie uplands. The flatter shores are usually bordered with small swamps.

Southwest of Manhattan the banks are usually 15 to 20 feet high. Northward they then drop to 10 or 12 feet, but again reach 20 feet at Egralharve, and at one point between Egralharve and Eagle Point, fully 30 feet. At Estherville Beach, north of Eagle Point, the banks are 20 feet high, but become lower, with slight exceptions, toward the north end of the lake.

The beach at the northern extremity of the lake is sandy, with swampy outliers, and the surface rises rather gradually to the prairie knobs and ridges to the north.

The eastern shore of the lake, quite to Okoboji, is bordered by abrupt banks and low bluffs. Near the north end the bluffs reach 45 feet in height, but northward they drop to 8 or 10 feet, with occasional headlands forming projections into the lake which reach a height of 25 feet, and at one point just south of the south line of section 1, of 30 feet. At Hayward's bay the banks drop to a sandy beach and there are no elevations near-by to the east. Southward from Hayward's Bay the banks vary from 10 to 20 feet in height, excepting just north of the Inn where the bluff rises 45 feet at one point, and continues at a height of over 20 feet for some distance. Below the Inn the banks are mostly abrupt and wooded, and the beaches are bowldery, as shown in Plate V, fig. 3.

Soundings were made in various parts of the lake with a 75-lb. weight, which served also for securing samples of the ooze

from the bottom. The greatest depth, 116 feet, was reached in these operations northwest from Ft. Dodge Point, and on a line drawn from the Inn to Pillsbury's Point. A depth of over 100 feet was also reached a little south of west of Pillsbury's Point.[3]

The greater part of the deeper portion of the lake, extending from opposite the lower portion of Emerson's Bay to a point opposite Manhattan Beach, varies from 60 to 80 feet in depth. The deepest portion of Emerson's Bay is about 35 feet; of Miller's Bay 35 feet; of the upper portion of the lake above Manhattan Beach 40 to 60 feet; and of the bay opposite Arnold's Park about 30 feet. Emerson's Bay is cut off from the main body of the lake by submerged reefs, thus forming practically an enclosed basin. This is also true of the bay north of Arnold's Park which is cut off by submerged reefs extending out from Ft. Dodge Point, and Pillsbury's Point. Miller's Bay is similarly partly cut off. These enclosed basins are very rich in vegetation, and furnish exceptional opportunities for the study of the aquatic flora of the lake. The inner portion of Miller's Bay, on the north side, opposite the Laboratory, offers the richest field for such study in all the region under discussion.

The lake border everywhere presents a greater or lesser abundance of aquatic vegetation and at many points offers excellent opportunities for zonal studies, the more conspicuous green vegetation extending to a depth of 30 to 35 feet. Beyond this depth diatoms are abundant, especially in the soft, brownish ooze which covers the bottom of the deeper portions of the lake to a depth of several feet. Excellent opportunities are also offered for plankton studies in this and other lakes, — a field as yet almost untouched in this region.

Center lake is the largest of the smaller lakes, and lies between the two Okoboji lakes. Again the groves represented on the map mark the position of steep banks along the margin of the lake, with bowldery banks as before, or, as on the south side of the lake, the surface is rough and rolling. A part of the sandy beach, illustrating the effect of "ice-shove," on the southeast shore, is shown in Plate VI, fig. 3. The hills on the southwest side rise to a height of more than 30 feet above the lake, and the

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3 The greatest depths in the lake, recorded in Bulletin no. 32 of the Engineering Experiment Station of the Iowa State College of Agriculture and Mechanic Arts, 1913, are 132 feet nearly west of Ft. Dodge Point, and 124 feet north of west of Pillsbury's Point.

west and southwest faces of the outer knobs are treeless. This lake is said to be 18 or 20 feet deep, but a careful exploration of its bottom has not yet been made.

The region to the southeast is rolling, with numerous kettleholes between ridges which were formerly well-wooded, but are now partially cleared. The map shows the original extent of the groves.

The entire region between the Okoboji lakes is more or less rolling, the eastern and southern parts being more elevated, though not much broken, and mostly covered with prairie. The hill southwest of Okoboji station rises about 55 feet above the lake. Between Center lake and West Okoboji lake the surface is somewhat broken, and kettleholes are frequent. A portion of one of these is shown in Plate VIII, fig. 2. Several dry knobs in this part are still covered with native prairie flora. Northward, toward the head of West Okoboji lake, these knobs and ridges become more massive, and the highest rise over 100 feet above the lake.

North of Center lake the surface is more or less rolling, with broad depressions occupied by swamps and small lakes. The groves shown around the small lakes lying north of the railway are also located on, or in the shelter of, abrupt banks which reach a height of 15 feet in some places.

The region to the northwest and west from the head of West Okoboji lake is mostly rolling upland prairie, with occasional sloughs or kettleholes, and it is cut by the valley of the Little Sioux, which is here bordered by rather gently sloping hills, and is practically treeless.

The region between West Okoboji lake and the Little Sioux river is of the same general character, but contains a large number of kettleholes, some of which are represented on the map. These kettleholes were formerly rich in marsh and aquatic plants, but many have been drained, and the tramping of stock has robbed them of their wealth of these plants, but some are still preserved, and well illustrate the character of the interesting marsh flora. Two of these, lying immediately west of the Lookout, are shown in Plate VIII, fig. 1.

The upper course of the valley of the main branch of the Little Sioux is practically treeless, and the bordering hills are not abrupt, but opposite Pratt lake the hills on the west side be-

come more abrupt, and are more or less forested. The bluffs and slopes along the river between Pratt lake and the "big loop" are also marked by frequent and sometimes extensive hillside bogs. The "big loop" of the Little Sioux sweeps around a great drift ridge, the more abrupt slopes of which are heavily forested. Below the "big loop" the western bluffs, where abrupt, are sparingly forested, as shown in Plate V, fig. 2.

Sylvan lake, Pratt lake, and Pillsbury lake are shallow, and similar to the smaller lakes and kettleholes already described. The groves along their shores also mark the rougher or more abrupt slopes or banks, as in the cases previously noted.

The rather narrow valley of the branch which drains the Gar lakes is practically treeless, and is bordered by rather gently rolling prairie.

Outlying points. — Two regions which lie beyond the limits of the territory mapped are worthy of note because of their interest to students of the Laboratory, as excursions may be easily made to both. A brief note concerning each is sufficient.

Ocheyedan Mound. — This is a gravelly knob southeast of Ocheyedan in Osceola County. Its flora is essentially that of the dry prairie hills west and north of the Laboratory. Rush lake, a large shallow kettlehole, with marshy shores, lies northeast of Ocheyedan. Its flora is essentially the same as that of the shallow lakes and kettleholes within our territory.

Estherville. — The valley of the Des Moines river at Estherville in Emmet County is of much interest to both botanists and zoologists. The steeper slopes bordering the valley are heavily wooded, and the alluvial bottom land furnishes both sand and marsh plants. The upland prairie between Estherville and Superior forms a part of the watershed between the Des Moines (or Mississippi) and the Little Sioux (or Missouri) drainage systems, and a sample of its flora is still preserved along the railway right of way between these two points.

ECOLOGICAL REGIONS

It will be observed that the region under discussion contains, within comparatively narrow limits, practically all the types of ecological areas which occur in Iowa, with the exception of rock ledges. Moreover the depth of West Okoboji lake, the extent of

the water and marsh surfaces, and the extent of still undisturbed prairie, and of prairie groves and fringes, make this in many respects the most interesting region in the state for ecological studies.

Each of these regions possesses the characteristic floral features of its type, and each presents points of special interest. To some of these brief attention is here given:

THE PRAIRIE

The prairie of this region is of special interest because it possesses certain peculiarities which throw light upon the cause of the treelessness of such areas. In its topography and flora it does not differ materially from much of the prairies of the state, but the presence of large bodies of water, with the prairie extending in many cases almost to their shore lines, constitutes an unusual features well worthy of attention.

In the paper entitled "The Prairies" [4] the writer offered evidence to show that factors operating in the atmosphere rather than in the soil were the chief cause of treelessness, and the following conclusions were reached:

"1. — Exposure to evaporation as determined by temperature, wind and topography is the primary cause of the treelessness of the prairies.

"2. — The prairie flora persists on the exposed areas because it is xerophytic.

"3. — Rainfall and drainage, while of importance, because determining the available supply of water in both soil and air, are not a general determining cause, both being frequently equal on contiguous forested and prairie areas.

"4. — Soils and geological formations are of value only in so far as they affect conservation of water; the porosity of the former determining its power of holding moisture, and the latter often determining topography.

"5. — Prairie fires were an effect rather than a cause and where acting as a cause were local.

"6. — Seed-dispersal probably accounts largely for the grouping of plant societies on the prairies, but does not account for the presence of the prairie flora as a whole.

4 Bulletin from the Laboratories of Natural History, State University of Iowa, vol. VI, pp. 169-240, 1911.

"7. — Other assumed causes, such as the bison, sea, etc., are of remote interest and not to be taken into account in any attempt at any explanation of the prairie as a whole."

Since the publication of that paper much additional evidence has been secured by the writer and his assistants, Messrs. Giddings and Boot, — a large part of it in the region under discussion. This evidence has only reinforced that previously secured, and has led to no important modification of the earlier conclusions, though an explanation of one of them may be desirable.

A literal interpretation of the first of these conclusions might give the impression that evaporation directly affected the exposed plants on prairies by causing a loss of water, and perhaps that this loss was directly proportional to the rate of evaporation, — though this was not intended. Repeated measurements of the amount of transpiration from prairie plants have shown that on the hot prairies when evaporation is greatest transpiration is least.[5] This, together with the evident depression of activity shown in wilting, etc., suggest that the physical factors which make for greater evaporation check the general activity of the plant and cause a diminution in transpiration, the latter being evidently merely a result and index of that activity. The wind exerts an influence not only by aiding evaporation, but also by its physical impact against the plant. Violent winds jar a plant, check its activity, and the result is soon shown in diminished transpiration. It is interesting to note that some of the prairie plants will stand much more of this jarring than structurally less protected mesophytic plants. Thus the writer has found that in indoor experiments with the leaves of *Clivia*, exposed to currents of air from electric fans, transpiration increased quite regularly with evaporation with increasing wind velocity up to about six miles per hour, and when the wind became more violent transpiration dropped, though evaporation still increased; while with some of the prairie plants the dropping of the transpiration curve did not begin until a velocity of twelve miles per hour had been passed. It is therefore evident that the physical factors acting

[5] While much work on transpiration of prairie and other plants has been done by the writer and his assistants, only a fragment has been published in Giddings' paper on "Transpiration of Silphium laciniatum L., and another was presented by Boot before the Atlanta meeting of the American Association for the Advancement of Science," and in part published in the Proceedings of the Iowa Academy of Sciences, vol. XXI, pp. 125-126, 1914.

upon a plant influence it otherwise than merely through evaporation, chiefly by stimulating or retarding its activities.

The region here under discussion furnishes abundant confirmation of the writer's earlier conclusions concerning the cause of the treelessness of the prairies, — indeed it presents the problem in a form of unusual interest. For that reason some effort has been made to work it out in greater detail, though only the more general conclusions can be presented within the limits of this paper.

In the first place we find the prairie here again upon surfaces most exposed to the summer winds and afternoon sun, while the groves are found upon the sheltered abrupt slopes, chiefly in close proximity to the lakes and rivers, as has been noted. It would appear that if the chief cause of the prairie is to be found in the evaporating agencies that make for drouth there should be a preponderance of forest in the vicinity of the numerous lakes of this region, for surely there is much vapor rising from these water surfaces, and the increased humidity of the air should make tree growth possible. And there *is* a greater amount of forest here than would be ordinarily found or expected in a region of such comparatively slight and gradual variation in topography. To a person traveling on West Okoboji lake, for example, it must appear that a large part of the region is forested, especially on the east side of the lake. Yet the forest forms a mere fringe, for the total forest area, while no doubt increased by the more favorable atmospheric conditions, is after all much less than that of the prairie, — a fact which is strikingly brought out by the map, on which the native forest areas are represented to scale as nearly as possible. At first sight a puzzling feature of this region is found in the fact that in many places the prairie extends almost to the water's edge. But an analysis of the entire region reveals a striking consistency in the distribution of forest and prairie along the lake and stream bodies, and moreover that distribution decidedly confirms the conclusions heretofore reached.

The location of the groves in this region on, or in the shelter of, abrupt slopes has already been emphasized. These slopes may be either on the leeward or the windward side with reference to the prevailing southerly and southwesterly winds of summer. Where they are on the leeward side, as at the Labora-

tory, on Twin Mounds, at intervals along the western and southern shores of the larger lakes, and along the west side of the Des Moines and Little Sioux rivers, the presence of the groves is consistent with the conclusions presented in the paper on "The Prairies." Where the slopes leading down toward the north or northward are gradual the currents of air follow the surface closely, producing exposure to wind quite as complete as on windward slopes, and in such cases the prairie extends quite to the water's edge. Illustrations may be observed at Terrace Park, in the treeless intervals along the shore between Manhattan and the head of the lake, and in the treeless intervals (where the slope will uniformly be found to be gradual) on the south and west sides of the larger lakes generally, and along the west side of the Little Sioux (see Plate V, fig. 2).

However, at a number of points groves are also found on, or at the base of, abrupt slopes which face the prevailing winds. Such groves are found along the west and north shores of the larger lakes, only, and are evidently made possible by the banking up of vapors from the lake against the high banks. Where such banks do not exist on the north and east sides of the lakes, and the surface rises gradually toward the north and east, there are no groves on the lake shore. Striking examples of this treeless condition are found at the head of West Okoboji lake, at Emerson's Bay, on the north shore of the lower part of East Okoboji lake, at the head of the same lake, and on the north and east shores of Spirit lake. At such places the vapors are swept away from the flatter shores and dissipated over the region lying beyond, and there is no accumulation of vapors under high banks in which a mesophytic forest flora might develop.

That the flatter leeward shores of the lakes, in which an accumulation of vapors is not possible, are comparatively xerophytic is shown by observations made in 1913 by Mr. D. H. Boot, under the writer's direction, and which are here in part recorded.

The observations were made at stations established along the north and south half-section line in section 16, Tp. 99 N., R. 36 W., north of East Okoboji lake. This is on one of the treeless gradual slopes rising northward from the lake. The following table gives the distances and elevations of the stations, the first being nearest the lake:

	DISTANCE FROM LAKE	ELEVATION ABOVE LAKE
a	10 feet	3 feet
b	190 feet	10 feet
c	985 feet	30 feet
d	1785 feet	75 feet

For illustration the observations of July 26th, 1913, are taken. The wind was from the southwest and varied in velocity from 10 to 15 miles per hour during the period of observations which continued from 7 A. M. until 3:30 P. M.[6]

The relative humidity and evaporation are given in the following tables:

RELATIVE HUMIDITY

Time	*Station a*	*Station b*	*Station c*	*Station d*
7:00 A. M.	.86	.78	.82	.78
9:00 A. M.	.73	.62	.65	.58
10:00 A. M.	.65	.60	.41	.58
11:00 A. M.	.60	.53	.54	.51
12:30 P. M.	.55	.51	.43	.49
2:00 P. M.	.62	.48	.42	.48
3:30 P. M.	.64	.49	.48	.54

EVAPORATION

Piche	3.85	2.57	3.21	3.29
Pan	94.20 cc.	63.30 cc.	87.25 cc.	93.00 cc.

It will be noticed that the relative humidity was much the same at the several stations and that at station *a*, nearest the lake, it was not much greater than at the more remote stations. It is also noteworthy that evaporation was slightly greatest nearest to the lake, probably because the exposure to wind was a little greater. Station *b*, just at the base of the steeper slope, shows the least evaporation. It was also most sheltered by its immediate surroundings. The temperature varied from 71° to 89° Fahrenheit at station *a* and from 73° to 91° F. at station *d*.

Unfortunately observations could not be made on the same day on the south side of the lake, but 16 days earlier, July 10th, silimar observations were made on Twin Mounds between the hours of 7 A. M. and 3 P. M. The wind was from the south with

6 For the evaporation observations the Piche evaporimeter, and open pans 150 mm. in diameter were used. The Piche unit is a tenth of a cubic inch, and the pan unit is a cubic centimeter.

a velocity of from 3 to 10 miles per hour, and the temperature ranged from 63° to 82° F. at the summit of the Mound, to 65° to 83° at the base, on its south or prairie side. (See Plate V, fig. 1.)

In the following table the relative humidity, and evaporation, are given as before. Station I, marked *a* in figure, is at the summit of the mound, 46 feet above the lake, station II, marked *b* in figure, at the middle of the slope, and stations III, marked *c* in figure and IV, marked *d* in figure, on the flatter portion near the base. Only the stations on the southern, or exposed, side are here considered.

RELATIVE HUMIDITY

Hour	*Station I*	*Station II*	*Station III*	*Station IV*
7:00 A. M.	.70	.76	.75	.71
9:30 A. M.	.53	.52	.55	.52
2:15 P. M.	.43	.41	.41	.46
3:00 P. M.	.38	.40	.38	.41

EVAPORATION

Piche	5.09	5.20	4.60	3.64
Pan	109.00 cc.	99.00 cc.	137.50 cc.	129.50 cc.

While this slope of the Twin Mounds is more exposed than the stations on the north side of the lake, and while there is no body of water to the south, the relative humidity is not much less and the evaporation but little greater. The wind velocity and temperature however were somewhat greater on the north side. It is evident, however, that atmospheric conditions are not materially different on the opposite sides of the lake, and that both sides are dry. Vapors evidently cannot rise sufficiently rapidly from the lake to materially increase the humidity of the atmosphere on the north side where there are no high banks or bluffs to arrest and accumulate them.

Where high banks thus arrest vapors they need not be so high that they could shelter a forest, but only sufficient to start one. The trees themselves then offer a certain amount of mutual protection, as may be clearly seen along the outer edges of the groves of this region where the outliers and border trees are stunted, and their leaves are often curled and withered on hot summer days, while the trees in the groves are more vigorous

and fresh. It is for this reason that in areas occupied by a succession of ridges, as on the southeast shore of East Okoboji lake and in the Hottes lake region, the forest extends even over the tops of the ridges.

The two rather large forest areas at Arnold's Park and on the peninsula between Miller and Emerson bays evidently owe their existence to the fact that they are partly surrounded by water, and that there are sufficient irregularities in the surface for a forest beginning. The peninsula between the bays is also penetrated by swamps, and a large swamp cuts it off from the prairie region to the west. Even with this advantage the western border of the forest is decidedly xerophytic, as is shown later.

One of the interesting treeless areas is that which lies north of Miller's Bay. It is shown in Plate II, fig. 1, and Plate VIII, fig. 3. Here the prairie extends down almost to the border of the lake. There are no abrupt slopes, and no groves. The opinion has been expressed by local observers that perhaps the Indians had burned the forest on this side. There is no evidence to show that a forest had ever existed here. Indeed the evidence at hand shows that this slope rising to the north has been exposed to exactly the same conditions as the general prairie, and that notwithstanding its proximity to the bay it is decidedly xerophytic.

On this slope stations were also installed at several points along a line 660 yards east of the west line of section 23, Tp. 99 N., R. 37 W., and Mr. Boot made a series of observations similar to those made in section 16, Tp. 99 N., R. 36 W. The observations for one day, illustrating the general result, are here recorded.[7] The day selected was June 26th, 1913. The wind was from the south and the temperature varied from 74° to 86° at station "a" (practically in the lake) and 75° to 90° F. at station "d." The observations were made at intervals from 8:00 A. M. to 6:00 P. M. The velocity of the wind varied little from six miles per hour at the several stations. The results are here given, the variation in relative humidity at the several stations being given in the first line, and evaporation as before measured in tenths of a cubic inch in the second line, and in cubic centimeters in the third line.

7 Mr. Boot will publish a more detailed account of these observations.

	STATION "a"	STATION "b"	STATION "c"	STATION "d"
Relative Humidity	.63—.75	.64—.78	.68—.86	.59—.74
Piche	3.28	2.80	3.30	3.60
Pan	102.00 cc.	97.70 cc.	80.20 cc.	129.00 cc.

Station "a" is located on the sand pit, station "b" is four feet from the lake shore, station "c" is at the base of the more abrupt slope 160 feet north of the lake, and station "d" is at the summit of the first elevation 940 feet north of the lake and 51 feet above its surface.

It is again notable that the greatest relative humidity is at the very base of the steeper slope (station "c"), even where the slopes are not abrupt. The differences in relative humidity are not great however, all the stations being quite dry during the warmest part of the day. Station "a" is quite remarkable in that it is on a narrow sand spit which extends some distance into the bay, and yet shows a high rate of evaporation, evidently because of its exposed position, and the inability of the vapors to rise sufficiently rapidly above the wind-swept lake to keep the air humid. The reason for the greater evaporation at station "d," and for the treelessness of this entire slope is to be found in the position of the tract with reference to surrounding topography. The higher prairie rises westward from the lake to the Lookout, but between the high point and the Laboratory there is a depression which forms a trough leading from the general prairie to the southwest directly to the slope north of the bay, as shown in figure 1. The southwesterly winds which sweep across the prairie are therefore directed to the slope in question, and render it quite xerophytic, notwithstanding the proximity of the lake. The vapors from the latter are usually swept to the opposite side and make possible the existence of the forest border along the east side of the lake.

The great variation in rate of evaporation at different points in the same vicinity is well illustrated by the series of observations made by the writer in August, 1909, at the Laboratory. Six stations were selected. Station 1 was located near the summit of the Lookout, facing southwest, — the most exposed station (see Plate I, fig. 1); station 2 was located near the west side of the Laboratory grounds, and near the edge of the "trough"

leading to the hills north of the bay (see Plate I, fig. 2); station 3 was located in front of the Laboratory cottage in a prairie opening (see Plate III, fig. 1); station 4 was in the small open bur-oak grove south of the cottage (see Plate III, fig. 1); station 5 was on the bank near the steps leading up from the Laboratory pier in a strip of prairie opening leading down from the west and northwest (see Plate III, fig. 2); station 6 was in the deep woods south of the Laboratory,

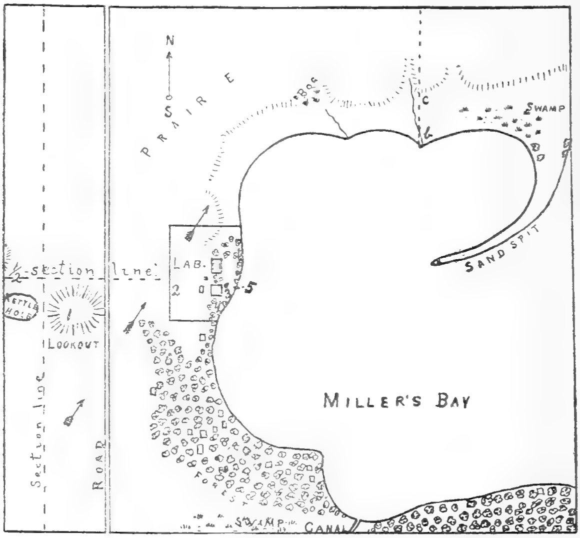

Fig. 1

and just north of the Beck spring. The elevation of station 5 was about 10 feet above the lake; that of stations 3 and 4 about 30 feet; of station 2 = 75 feet; and station 1 = 152 feet.* The locations of the stations are shown in figure 1. The observations were made on six consecutive days, August 6 to 11 inclusive, during the following periods: Aug. 6th, 9 A. M. to 7 P. M.; Aug. 7th, 8th, and 9th, 7 A. M. to 7 P. M.; and Aug. 10th and 11th, 8:30 A. M. to 7:00 P. M. For the evaporation observations open pans 150 mm. in diameter were used, and the loss was measured in cubic centimeters. The general results are given

* The last two elevations were furnished by Prof. A. O. Thomas. They were determined July 26, 1910, when the elevation of the lake surface above sea-level was 1,230 feet.

in the following tables, the figures at the top indicating stations and those at the left the dates:

1909 Aug.	*Evaporation from pans* 1	2	3	4	5	6	*Relative Humidity*
6	97 cc.	85 cc.	74 cc.	11 cc.	0 cc.	0 cc.	.55 – .78
7	49 cc.	65 cc.	39 cc.	16 cc.	9 cc.	0 cc.	.59 – .81
8	18 cc.	4 cc.	15 cc.	0 cc.	0 cc.	0 cc.	.72 – .91
9	48 cc.	45 cc.	48 cc.	8 cc.	26 cc.	0 cc.	.50 – .97
10	100 cc.	100 cc.	77 cc.	0 cc.	67 cc.	0 cc.	.55 – .84
11	97 cc.	96 cc.	63 cc.	8 cc.	28 cc.	0 cc.	.53 – .87

At the same time the record of temperature, of wind, and of sky was as follows, the wind velocity being given in miles per hour:

Aug.	*Temperature*	*Wind Vel.*	*Wind Direction*	*Sky*
6	75° – 88°	7 – 15	S.	Clear
7	70° – 83°	6 – 13	S.; S. E.	Hazy
8	74° – 82°	0 – 10	S., W., N. W.	Cloudy
9	70° – 92°	Gusts	S. E., S., S. W.	Cloudy
10	77° – 91°	0 – 13	S., W.	Clear
11	81° – 94°	0 – 14	S.	Some clouds

The great variation in evaporation is especially striking, and seems to be greater than might be expected from the more limited variation in relative humidity.

On the cloudy days, Aug. 8th and 9th, there was a distinct diminution in evaporation, due in part also to reduced wind velocity. Stations 1 and 2 were most exposed and on the whole showed the highest evaporation, especially when the wind was from the southwest on a clear day. The amount of evaporation at station 3 was surprisingly great, inasmuch as the station was located near the lake on one of the strips of prairie which here reach the edge of the lake bluff. This station is somewhat exposed to the west and southwest, and to the southeast. When the prevailing direction of the wind was from the southwest, and the lake vapors were carried away from this shore, the rate of evaporation was high.

The results at station 5 are also interesting. This station faced the lake and was only a few feet from the water. When the wind was from the southwest evaporation was greatest, as on

the 9th, 10th, and 11th of August; when the wind was from the south or southeast and banked the vapors around this station, evaporation was much reduced. Station 6 was so completely sheltered from both sun and wind that evaporation was reduced to a negligible quantity.

The foregoing facts emphasize the importance of atmospheric factors in influencing the distribution of the prairie and forest floras. It must not be assumed that soil conditions have no influence, for the temperature and fineness of the soil, the amount of free soil water, and perhaps other soil qualities, undoubtedly produce some effect, but the determining causes of relative prairie and forest distribution evidently lie in the atmosphere rather than in the soil.

I — THE PRAIRIE FLORA

The writer first entered upon this work at a time when a large part of the region west of the lakes was an unbroken prairie, and at intervals he has watched the latter in all its moods and phases to the present day. Excepting for the disappearance of the native flora in the cultivated areas there has been little change in the character of the prairie, and where its surface has remained unbroken its flora has suffered but little by elimination or by the addition of introduced forms, and locally suggests even today the splendor of the great prairie flower-garden which once covered the greater part of our state in the mid-summer season.

The prairie flora of this region does not differ materially from that of other corresponding parts of the state. As has been repeatedly pointed out it is distinctly xerophytic. The plants present the usual narrow, reduced, rigid leaves (or if the leaves are broader they are leathery, or are covered with hairs or scales), the large root system, the varied devices for protection, such as thick cutin, protected stomata, compact leaf tissue, water storage tissues, and resinous or milky secretions, all of which characterize xerophytes. The compact tissues are well illustrated in figs. 2, 3, and 4, on Plate IV; [8] the cutinized epidermis in figs. 1 and 2; trichomes in figs. 2, 3, and 4; enlarged epidermal or bulliform cells, and companion cells surrounding the vascular bundles, in fig. 1 (both water reservoirs); or with additional connecting

[8] These and the following figures are copied from the still unpublished thesis of Miss Ella Shimek, on the "Ecological Histology of Prairie Plants." The drawings were made from sections of leaves collected near the Lakeside Laboratory.

plates of similar cells in fig. 4; or forming transverse or vertical plates, as in fig. 3.

The prairie plants also exhibit the ordinary narrow, elongated palisade cells so common in xerophytes which are exposed to strong light on the treeless tracts which form their habitat. Where the leaf is covered with strong cutin, or with abundant trichomes, either of which reduces the intensity of the entering light, the palisade cells are more rounded, as illustrated in Plate IV, fig. 2.

It is because of these xerophytic adaptations that the prairie flora is able to take possession of the exposed tracts on which it is ordinarily found. The mesophytes of the forest usually perish in a few hours if transferred to these exposed tracts, as the writer has determined by repeated experiments.

The flowering plants form the dominant vegetation of the prairies. The few *Thallophyta* are for the most part parasitic on flowering plants, the prairie *Bryophyta* are almost a negligible quantity in this region, and the *Pteridophyta* are represented only by the genus *Equisetum*.

An inspection of the list of xerophytic plants of this region (compare especially columns 1 to 4 and 5 to 6 in the vascular list) again shows that the flora of the sandy areas is essentially the same as that of the prairie, a fact which emphasizes the conclusion that fineness of the soil does not determine the distribution of the prairie plants.

Very much more could, and probably should be written concerning the peculiarities of plant associations on the prairies. Most of the species have their seeds distributed by wind, and the variability of this factor produces marked changes from season to season in the relative abundance and distribution of annual plants, and in the end strongly influences and finally determines the distribution of the perennial plants. The accident of distribution because of this fluctuating factor enters largely into the determination of particular groupings, and suggests the inadvisability of basing ecological classifications or determination of prairie plant formations on the particular grouping which is presented in a comparatively restricted area. It is for this reason that the quadrat method of study of relative distribution of prairie plants has proven unsatisfactory and misleading.

A comparison of the floras of two very similar localities will

prove of interest in this connection. The Lookout just west of the Laboratory, and the hill just north of Miller's Bay, are very similar in exposure, soil, and general aspect of the flora, and are separated by a comparatively short distance. The total number of species of vascular plants collected in these localities is 135. Of these 99 were found on the Lookout, and 90 on the hills north of the Bay. The number of species common to both localities is 54, thus leaving 45 additional species for the Lookout, not found on the hill north of the Bay, and 36 in the latter locality not found on the Lookout. Neither of these groups of species found only in one of the two localities reveals or suggests a peculiarity of the locality which might account for the difference. Other restricted localities in this region show entirely different combinations of these species, and the natural conclusion is that the floras of the two localities differ simply because of the accident of distribution which leaves many species of prairie plants in restricted belts and groups.

A more thorough study of the region will no doubt bring other species to light. The present list includes with few exceptions only the species which were collected, and specimens of which are preserved in the herbarium of the State University of Iowa.

The Prairie List

The vascular plants and especially the *Spermatophyta* form the bulk of the prairie flora. The *Thallophyta*, and the *Bryophyta* have but scant representation.

Subkingdom I THALLOPHYTA

A few fungi and lichens occur. The following have been collected; fungi marked by an asterisk belong to Mr. Giddings' list:

Fungi

* *Basidiophora entospora* B. & C., on *Iva xanthiifolia.*

* *Cystopus candidus* (Pers.) Lev., on *Lepidium apetalum.*

* *Peronospora leptosperma* DBy., on *Artemisia ludoviciana.*

* *Peronospora parasitica* (Pers.) DBy., on *Lepidium apetalum.*

Erysiphe cichoracearum DC., on *Grindelia squarrosa.*

* *Claviceps purpurea* (Fr.) Tul., on *Agropyron Smithii.*

* *Æcidium compositarum* Mart., on *Ambrosia trifida.*

* *Æcidium oenothera* Pk., on *Oenothera biennis.*

* *Phragmidium subcorticium* (Schr.) Went., on *Rosa pratincola.*

* *Puccinia asparagi* DC., on *Asparagus officinalis.*

* *Puccinia caricis* Schum., on *Urtica gracilis.*

* *Puccinia helianthi* S., on *Helianthus grossesserratus,* and *H. tuberosus.*

* *Puccinia menthae* Pers., on *Monarda mollis.*

* *Puccinia silphi* S., on *Silphium laciniatum.*

* *Puccinia xanthii* Schw., on *Xanthium speciosum.*

Uromyces fabæ (Pers.) D. & B., on *Lathyrus venosus.*

* *Mycenastrum spinulosum* Pk., prairie at the head of West Okoboji lake.

Dr. Arthur also reported the following additional species from this region.[9]

Ustilago caricis Pers., on *Carex pennsylvanica.*

Puccinia graminis Pers., on grasses.

Puccinia rubigovera (DC.) Wint., on *Elymus canadensis.*

Puccinia sporoboli Arth., on *Sporobolus heterolepis.*

Puccinia andropogonis Schw., on *Andropogon furcatus* and *A. scoparius.*

Puccinia vexans Farl., on *Bouteloua curtipendula* and *Sporobolus brevifolius.*

Puccinia epilobi DC., on *Œnothera biennis.*

Uropyxis amorphae (Curt.) Schw., on *Amorpha microphylla.*

Lichens

But few species of lichens are found on the prairie and these are mostly on bowlders. The following species were collected:

On Prairie Bowlders

Lecanora muralis saxicola (Poll.) Tuck.

Lecanora cinerea (L.) Som.—Common.

Lecanora Hageni Ach. calcareous bowlders.

Placodium cinnabarinum (Ach.) Anz.

Placodium aurantiacum (Light.) Hepp.

Placodium vitellinum (Hoff.) Hepp.

Placodium vitellinum aurellum (Hoffm.) Tuck.

Placodium elegans (Link) DC.

Treloschistes chrysophthalmus (L.) Th. (Rare).

Rinodina oreina (Ach.) Mass. Very common.

Physcia caesia (Hoff.) Nyl.

Physcia stellaris L.

Verrucaria fuscella (Turn.) Ach.

Verrucaria pyrenophora (Ach.) Nyl.

Endocarpon pusillum (Hedw.) calcareous bowlders.

On Old Pine Fences

Lecidea myriocarpoides Nyl.

Placodium pyraceum (Ach.) Fink.

Acolium tigillare (Ach.) S. F. Gr.

Subkingdom II BRYOPHYTA

So far as observed in this region the bryophytes are represented only by the following species:

Ephemerum sessile (B. & S.) Müll. On ground on dry hills.

Grimmia apocarpa (L.) Hedw. On bowlders.

For the sake of compactness and to avoid useless repetition of

9 Bulletin of the Iowa Agricultural College, 1884. Locality given as "Dickinson county" in each case, but evidently referring chiefly to our territory.

names, special symbols are employed in the list of vascular plants here included.

The numbers in the columns I-VIII indicate the abundance of the species. This can be indicated in a general way only as it varies in different parts of the same area, the accident of distribution playing an important part; and it also varies in different years. The following numbers are employed:

1 — Denotes locally dominant species. They may be scattered in other parts of the territory.

2 — Denotes principal species — those which form a conspicuous part of the flora but do not dominate.

3 — Marks species which are quite generally distributed in a given area, but do not ordinarily form a conspicuous part of the flora. These are the fairly common scattered species.

4 — For the rare species, whose occurrence is exceptional, and often quite local.

5 — For very rare species.

The letter following the name of the plant in the list refers to one of the following groups:

a — The most characteristic plants of the prairie, — those most widely distributed in the region, as well as elsewhere on prairies. They are by no means uniformly distributed, but are everywhere characteristic of the prairies.

b — The species usually found only in very dry places, on gravelly ridges, etc. These are the extreme xerophytes of our region, and are chiefly western in distribution.

c — The species which are more frequently found in rather moist, open places, or sometimes habitually occur only on moist grounds and only exceptionally on the prairie.

d — The species which prefer the open borders of thickets, and which usually extend out over the prairie chiefly in the vicinity of such borders.

e — Plants which are usually, or always, found upon sandy areas (other than moist beaches), but always associated with the dominating prairie vegetation.

f — Species introduced, or occurring as weeds, but which are quite well established even on unbroken prairie.

The Roman numerals which head the columns refer to localities as follows:

I — A group of gravelly knobs and ridges including the Look-

out west of the Laboratory, the somewhat higher knob northwest of it, the ridge north of Miller's Bay, and a gravelly knob at the head of West Okoboji lake.

II — Similar gravelly knobs east of the head of West Okoboji lake, and east and northeast of the Inn. These two groups typify the flora of all the gravelly ridges of the region, such as Twin Mounds, the ridge southeast of Terrace Park, and the knobs in the Spirit lake region.

III — The general rolling upland prairie west of West Okoboji lake, somewhat less xerophytic than I, with a fine drift soil of somewhat variable quality.

IV — The general prairie between East and West Okoboji lakes. This is also mostly somewhat elevated and rolling, and includes the region between the head of West Okoboji lake and Spirit lake. The groups III and IV include the general prairie flora of the entire region.

V — The sandy prairie at Terrace Park and west of Emerson's Bay, and similar prairie at the north end of West Okoboji lake. This represents older sandy beaches which are not now ordinarily reached by the waves.

VI — A similar area between East Okoboji and Spirit lakes, and another on the north side of Spirit lake.

VII — This column includes the prairie species which have been found in the more or less semi-xerophytic borders and openings in groves along the west side of West Okoboji lake, where they mingle more or less with forest species.

VIII — Similar areas along the east side of West Okoboji lake, including the banks south of Pillsbury's Point.

Collections have been made over the entire area mapped but it would be impossible to give all the details of distribution without expanding this paper beyond reasonable limits. It is believed that the presentation of these regional lists will give a sufficient insight into the nature and distribution of the prairie flora of the region.

	I	II	III	IV	V	VI	VII	VIII
Subkingdom III PTERIDOPHYTA								
Family *Equisetaceæ*								
Equisetum arvense L. i			4	4				
Equisetum hyemale robustum (ABr.) A. A. Eaton c				4		5		

		I	II	III	IV	V	VI	VII	VIII
Equisetum lævigatum A. Br.	a			3	4				
Equisetum variegatum Schl.	b	5			5				
Equisetum variegatum Jesupi A. A. Eat.	b				5				
Subkingdom IV SPERMATOPHYTA									
Subclass MONOCOTYLEDONEÆ									
Family *Gramineæ*									
Andropogon furcatus Muhl.	a	3		3	3		4		4
Andropogon scoparius Michx.	a	3	4	3	3				4
Sorghastrum nutans (L.) Nash	a	4		4	4				
Panicum capillare L.	i	4		4	4	4	4		
Panicum depauperatum Muhl.	b	4		4	4				
Panicum Leibergii (Vasey) Scrib.	a			4	4				4
Panicum Scribnerianum Nash	a	3		3	3	4	4		4
Panicum virgatum L.	a	4		4	4		4		
Stipa spartea Trin.	a	2	3	2	4	4	4		
Aristida basiramea Engelm.	b	5	5		5				
Muhlenbergia mexicana (L.) Trin.	c					4			
Muhlenbergia racemosa (Michx.) BSP.	c			4	4	4			
Sporobolus asper (Michx.) Kunth	b	4							
Sporobolus brevifolius (Nutt.) Scrib.	b				4				
Sporobolus crytandrus (Torr.) A.Gr.	e				4	4			
Sporobolus heterolepis Gray	b	4			4				
Agrostis alba vulgaris (With.) Thurb.	a	3		3	4				
Agrostis hyemalis (Walt.) B.S.P.	b	4		4	4				
Sphenopholis obtusata (Michx.) Scrib.	b			5	5				
Koeleria cristata (L.) Pers.	a	2	3	2	3	4			
Spartina Michauxiana Hitch.	c				4				
Bouteloua curtipendula (Michx.) Torr.	a	3	2	3	3				
Bouteloua hirsuta Lag.	b	4	4	5					
Bouteloua oligostachya (Nutt.) Torr.	b	4	5	4		5			
Poa compressa L.	i		3	3	4			4	
Poa pratensis L.	i	4		4	3	4	4		
Poa triflora Gilib.	c	4		3			4		
Festuca octoflora Walt.	e	5				4			
Agropyron caninum (L.) Beauv.	a	4		4					
Agropyron Smithii Ryd.	a	3		3	3	4	4		
Agropyron tenerum Vasey	a	3		3	4	3	4		
Hordeum jubatum L.	i	3		3	3	4			
Elymus canadensis L.	a	3	4	3	3	3	3	3	3
Elymus Macounii Vasey	a	4	4	3	4				

		I	II	III	IV	V	VI	VII	VIII
Elymus striatus Willd.	a							5	
Elymus striatus arkansanus (S. & B.) Hitch	a			4					
Elymus robustus Scrib. & J. G. Sm.	c			3					
Elymus virginicus L.	d			4					
Family *Cyperaceæ*									
Cyperus Schweinitzii Torr.	e					4	3		
Stenophyllus capillaris (L.) Britt.	e					5			
Carex Bicknellii Britt.	a				4				
Carex festucacea Schk.	a	3		3	3	3	3		3
Carex gravida Bail.	a			4					
Carex gravida laxifolia Bail.	c			4					
Carex pennsylvanica Lam.	a	4			4	4			
Carex scoparia Schk.	a			4					
Carex stenophylla Wahl.	e					5			
Carex tetanica Meadii (Dew.) Bail.	a	4		4		4			
Carex tribuloides Wahl.	a			4					
Carex trichocarpa Muhl.	c			4					
Carex vulpinoidea Michx.	c			5					
Family *Commelinaceæ*									
Tradescantia bracteata Small	a	4		4	4				
Tradescantia brevicaulis Raf.	b	4			4				
Family *Juncaceæ*									
Juncus tenuis Willd.	d							4	
Family *Liliaceæ*									
Zygadenus chloranthus Rich.	a				4				
Allium canadense L.	a	4	4						4
Allium stellatum Ker.	a	3	3	3	3		3		3
Lilium philadelphicum L.	a			5					
Smilacina stellata (L.) Desf.	d			4				4	4
Polygonatum commutatum (R. & S.) Dietr.	d							4	
Family *Amaryllidaceæ*									
Hypoxis hirsuta (L.) Cov.	a	4			4				
Family *Iridaceæ*									
Sisyrinchium campestre Bick.	a	3	3	3	3			4	
Subclass DICOTYLEDONÆ									
Family *Fagaceæ*									
Quercus macrocarpa depressa Nutt.	d								4
Family *Urticaceæ*									
Urtica gracilis Art.	c						4		
Family *Santalaceæ*									
Comandra umbellata Richardsonian (Fern.)	a	3	4	4	4	4			
Family *Polygonaceæ*									
Polygonum convolvulus L.	i	4		4	4	4			

		I	II	III	IV	V	VI	VII	VIII
Polygonum pennsylvanicum L.	i	4							
Polygonum ramosissimum Michx.	a			4	4		4		
Rumex altissimus Wood	a			4					
Rumex brittanica L.	c						4		
Family *Chenopodiaceæ*									
Chenopodium Boscianum Moq.	e					5			
Chenopodium leptophyllum Nutt.	e						4		
Salsola kali tenuifolia G.F.W. Mey.	i			4	4	3	3		
Family *Amaranthaceæ*									
Amaranthus blitoides Wats.	a				4				
Amaranthus retroflexus L.	i						4		
Family *Nyctaginaceæ*									
Oxybaphus albidus (Walt.) Sweet	a	3	4	3					
Oxybaphus hirsutus (Pursh) Sweet	b			4	4				
Oxybaphus nyctagineus (Michx.) Sweet	a	4	4	4	4	4	4	4	
Family *Caryophyllaceæ*									
Silene antirrhina L.	a	3	4	4	4	4	4		
Silene stellata (L.) Ait. f.	d	4	4	4	4	4	4	4	4
Family *Ranunculaceæ*									
Ranunculus abortivus L.	d			5	5				
Ranunculus fascicularis Muhl.	a			4					
Ranunculus rhomboideus Goldie	a			4	4				
Thalictrum dasycarpum F. & L.	c			3	3		4	3	3
Anemone canadensis L.	c			4	4				
Anemone cylindrica Gray	a	3		3	3	3			3
Anemone patens Wolfgangiana (Bess.) Koch	a	2	3	3	4	4			
Aquilegia canadensis L.	d						5	4	
Delphinium Penardii Huth.	a	3		3	3				
Family *Fumariaceæ*									
Corydalis micrantha (Eng.) Gray	e				5	5			
Family *Cruciferæ*									
Lepidium apetalum Willd.	a	3	3	3	3	3	3		
Sisymbrium canescens Nutt.	a			4	4				4
Sisymbrium canescens brachycarpon (Rich.) Wats.	a				4				
Erysimum cheiranthoides L.	d						5		
Arabis hirsuta (L.) Scop.	d			4		4		4	
Family *Capparidaceæ*									
Polanisia graveolens Raf.	e					3	3		
Polanisia trachysperma T. & G.	e				5	2	3		
Family *Saxifragaceæ*									
Heuchera hispida Pursh	a	5		4	5				5
Ribes gracile Michx.	d							4	

		I	II	III	IV	V	VI	VII	VIII
Family *Rosaceæ*									
Fragaria vesca americana Port.	d	4	4					4	
Fragaria virginiana Duches.	a	3		3	3	4		3	
Potentilla arguta Pursh	a	4	4	4		5	5		
Potentilla monspeliensis L.	c	4		4	4	4	4		4
Potentilla paradoxa Nutt.	e					3	3		
Rubus occidentalis L.	d							4	
Rosa pratincola Greene	a	3	4	3	3	4			
Rosa Woodsii Lindl.	a	4							
Family *Leguminosæ*									
Desmanthus illinoensis (Michx.) MacM.	e						3		
Baptisia leucantha T. & G.	a			5					
Trifolium repens L.	i						4		
Psoralea argophylla Pursh	a	3	3	3	3				
Psoralea esculenta Pursh	a	4	4	4	4	4			
Amorpha canescens Pursh	a	3	4	3	4				4
Amorpha microphylla Pursh	b	5	5						
Dalea alopecuroides Willd.	e					5	4		
Petalostemum candidum Michx.	a	3	4	3	3		4		
Petalostemum purpureum (Vent.) Ryd.	a	3	3	3	3	4	4		
Astragalus canadensis L.	a	3		3	3	4	4		4
Astraglus caryocarpus Ker.	a	3	4	3	4	5			
Oxytropis Lamberti Pursh	b	4	3	4	5				
Glycyrrhiza lepidota (Nutt.) Pursh	a			4	4				
Desmodium canadense (L.) DC.	a	4		3	4	4		4	4
Desmodium illinoense Gray	a						5		
Lespedeza capitata Michx.	a	4		3	4		4		
Lespedeza leptostachya Engelm.	e			5		4			
Vicia americana Muhl.	a			4	4	5			
Lathyrus venosus Muhl.	d	4		4	4		4	4	4
Strophostyles helvolus (L.) Britt.	e						3		
Strophostyles pauciflorus (Benth.) Wats.	e				4	4	4		
Amphicarpa Pitcheri T. & G.	d			4	4				4
Family *Linaceæ*									
Linum sulcatum Rid.	a	4	4	4	4		4		
Family *Oxalidaceæ*									
Oxalis filipes Small	d	3		4	4	4			
Oxalis stricta L.	a	3	4	3	3			4	
Oxalis violacea L.	a	4		4	4			4	
Family *Polygalaceæ*									
Polygala verticillata L.	a			4					

		I	II	III	IV	V	VI	VII	VIII
Family *Euphorbiaceæ*									
Acalypha virginica L.	d				4				
Euphorbia corollata L.	a				4				
Euphorbia heterophylla L.	e						4		
Euphorbia maculata L.	a				4				
Euphorbia Preslii Guss.	e					3	3		
Euphorbia serpyllifolia Pers.	a	3		3	4	4			
Family *Anacardiaceæ*									
Rhus glabra L.	d			4			4		
Rhus toxicodendron L.	d	4		4	4		4		
Family *Rhamnaceæ*									
Ceanothus americanus L.	a	4		4	4				4
Family *Vitaceæ*									
Vitis vulpina L.	d			4			4		
Family *Violaceæ*									
Viola cucullata Ait.	c			4		4	4		
Viola pedatifida G. Don.	a	3		3	4	4		4	
Viola sororia Willd.	d							4	
Family *Onagraceæ*									
Œnothera biennis L.	a	4	4	4	4	4	4		4
Œnothera serrulata Nutt.	b	3	3	3	3	3			
Family *Umbelliferæ*									
Eryngium yuccifolium Michx.	a	4		4	4				
Zizia aurea (L.) Koch	d			3	4	4			4
Tænidia integerrima (L.) Drude	d							4	
Family *Gentianaceæ*									
Gentiana puberula Michx.	a	4		4	4				
Family *Apocynaceæ*									
Apocynum androsæmifolium L.	d								4
Apocynum cannabinum L.	a			4	4				
Apocynum cannabinum hypericifolium (Ait.) Gray	c			3	4				
Family *Asclepiadaceæ*									
Asclepias ovalifolia Dcne.	d							5	
Asclepias Sullivantii Engelm.	a			4	4				
Asclepias syriaca L.	a	4		4	4	4	4		4
Asclepias tuberosa L.	a			3	4		4		
Asclepias verticillata L.	a			3	3	4	4		4
Acerates lanuginosa (Nutt.) Dcne.	b	5							
Acerates viridiflora Ell.	a	3		3	3				
Acerates viridiflora lanceolata (Ives) Gray	a	3		3	3		4		
Acerates viridiflora linearis Gray	b	4		4					
Family *Convolvulaceæ*									
Convolvulus sepium L.	a			4	4		4		
Cuscuta glomerata Chois.	d	3		4	4				

		I	II	III	IV	V	VI	VII	VIII
Family *Polemoniaceæ*									
Phlox pilosa L.	a	3		4	3			4	
Family *Hydrophyllaceæ*									
Ellisia nyctelea L.	d				4				
Family *Boraginaceæ*									
Lappula Redowskii occidentalis (Wats.) Ryd.	e						4		
Lithospermum angustifolium Michx.	a	3	4	4	4	4	4		
Lithospermum canescens (Michx.) Lam.	a	3	4	3	4	4			
Onosmodium occidentale Mack.	a	4	4	4	4	4	4		
Family *Verbenaceæ*									
Verbena hastata L.	c					4	4		
Verbena stricta Vent.	a	3	3	3	3	3	3		
Verbena urticæfolia L.	i							4	
Family *Labiatæ*									
Teucrium canadense L.	e						4		
Isanthus brachiatus (L.) BSP.	e				4				
Scutellaria parvula Michx.	a		4		4				
Scutellaria parvula ambigua (Nutt.) Fern.	a	4		4	4				
Stachys palustris L.	c	4		4		4	4		
Monarda mollis L.	a	3	4	3	4	4	4	3	3
Hedeoma hispida Pursh	e				4	4			
Pycnanthemum flexuosum (Walt.) BSP.	a	3		3	4			4	
Pycnanthemum virginianum (L.) D. & J.	d			4					
Family *Solanaceæ*									
Solanum rostratum Dunal	i			4	4				
Physalis pruinosa L.	a	3		3	4	4	4		
Physalis pubescens L.	a	4		4	4	4			
Family *Scrophulariaceæ*									
Scrophularia leporella Bick.	a	4	4	4	4	4	4		
Pentstemon grandiflorus Nutt.	e					4			
Veronica virginica L.	d	4		4	4				
Gerardia aspera Dougl.	b	4	4	4					
Castilleja sessiflora Pursh.	b	4	4	4	4				
Pedicularis canadensis L.	a	3		4	4				
Family *Plantaginaceæ*									
Plantago Rugelii Dcne.	d						4		
Family *Rubiaceæ*									
Galium boreale L.	a	3		4	4				4
Family *Caprifoliaceæ*									
Symphoricarpos occidentalis Hook.	d		4	4	3	4		4	3

		I	II	III	IV	V	VI	VII	VIII
Family *Lobeliaceæ*									
Lobelia spicata Lam.	c			4	4				
Family *Compositæ*									
Vernonia fasciculata Michx.	c			3	4			4	
Vernonia noveboracensis Willd.	a			5					
Kuhnia eupatoroides corymbulosa T. & G.	a	3	4	3	4		4		
Liatris cylindracea Michx.	e					5			
Liatris punctata Hook.	b	3	3	3	3	4			
Liatris pycnostachya Michx.	c			4	3				
Liatris scariosa Willd.	a	3	3	3	3				
Liatris squarrosa Willd.	a			5					
Grindelia squarrosa (Pursh.) Dunal.	i				3				
Solidago canadensis L.	d	4		3	4	4	3	4	4
Solidago graminifolia (L.) Salis.	a			4	4		4		
Solidago missouriensis Nutt.	a	3	3	3	3				4
Solidago nemoralis Ait.	a	3	3	3	3				
Solidago rigida L.	a	3	3	3	3	3	4		4
Solidago serotina Ait.	e				4			4	4
Solidago serotina gigantea (Ait.) Gray	c				4	4			
Solidago speciosa angustata T. & G.	a	4	4	4	4	4			
Aster ericoides L.	d								5
Aster lævis L.	a	3	4	3	3				4
Aster multiflorus exiguus Fern.	a	3	4	3	3	4	4		4
Aster novæangliæ L.	a				4	4			
Aster oblongifolius Nutt.	b	4	3						
Aster ptarmicoides T. & G.	b	3	3	4	4				
Aster sagittifolius Wedem.	d							4	4
Aster sericeus Vent.	b	4	4	4	4	4			
Erigeron annuus (L.) Pers.	d				4				
Erigeron canadensis L.	i	3		3	3	4	4		
Erigeron divaricatus Michx.	i				4				
Erigeron philadelphicus L.	d		5	4	4		4	4	
Erigeron ramosus (Walt.) BSP.	a	3	3	3	3		4		
Antennaria campestris Ryd. (?)	a				4				
Antennaria neglecta Greene	a		4		4			4	
Antennaria neodioica Greene	a	3		4	4			4	
Antennaria plantaginifolia (L.) Rich.	d				5				
Silphium laciniatum L.	a	4		4	4				
Silphium perfoliatum L.	c				4		5		
Iva xanthiifolia Nutt.	a			2	3		3		

		I	II	III	IV	V	VI	VII	VIII
Ambrosia artemisiifolia L.	i	3	4	3	3	4	4		4
Ambrosia psilostachya DC.	e			4		4	4		
Ambrosia trifida L.	c			3		3	3		
Ambrosia trifida integrifolia (Muhl.) T. & G.	e			4	4	4			
Xanthium commune Britt.	e				4	4			
Xanthium speciosum Karn.	b	3					3		
Heliopsis scabra Dunal.	a	3		3	3	4	4		4
Bidens vulgata puberula (Wieg.) Greene	e						4		
Brauneria angustifolia (DC.) Hell.	b	3	3	3	4				
Lepachys columnaris (Sims) T. & G.	i				5				
Lepachys pinnata (Vent.) T. & G.	a	3		3	3	4	4	4	4
Helianthus grosseserratus Mart.	c			4	4	4	4		4
Helianthus Maximiliani Schrad.	a			3	4				
Helianthus scaberrimus Ell.	a	3	3	3	3	4	4		
Helianthus tuberosus L.	d			4	4				3
Coreopsis palmata Nutt.	a	3	3	3	3				
Helenium autumnale L.	c			4			5		
Achillea millefolium L.	a				4			4	
Achillea lanulosa Nutt.	a		5		4				
Artemisia caudata Michx.	e		4	4		3	3		4
Artemisia dracunculoides Pursh.	a	3	4	3	3	4	4		4
Artemisia ludoviciana Nutt.	a	3		3	4	4	4		4
Artemisia serrata Nutt.	a						4		
Cacalia tuberosa Nutt.	a				4				
Senecio balsamitæ Muhl.	c			4		4			
Senecio integerrimus Nutt.	e					4			
Senecio plattensis Nutt.	a	4							
Cirsium canescens Nutt.	b.	3			3		4		
Cirsium discolor (Muhl.) Spreng.	a	3		3	3				
Cirsium iowensis (Pam.) Fern.	a	3		3	3		4		
Cirsium iowensis Crattyi Pam.	d	3		3	4				4
Cirsium undulatum (Nutt.) Spr.	a			4					
Lactuca canadensis L.	a			3	4	4			4
Lactuca ludoviciana (Nutt.) Ridd.	a	3		3	3	4	4		
Lactuca pulchella (Pursh) DC.	e						4		
Lactuca sagittifolia Ell.	a			4			4	4	
Lygodesmia juncea (Pursh) D. Don	b	3	3	3	4				
Agoseris cuspidata (Pursh) Steud.	a	4				4			
Prenanthes aspera Michx.	a	4		4					
Prenanthes racemosa Michx.	c			5	5				
Hieracium canadense Michx.	d				4				4

The following additional introduced weeds now frequently appear in the prairie region, more especially where the surface has been disturbed, as along roadsides; and they are not infrequent on the drier sandy beaches. The weeds restricted to gardens and farms are not here included.

Several native species, such as *Solidago rigida, Iva xanthiifolia,* etc., have also become troublesome weeds.

Prairie weeds

Asparagus officinalis L.
Anthemis cotula L.
Brassica nigra (L.) Koch.
Brassica arvensis (L.) Ktze.
Bromus ciliatus L.
Bromus secalinus L.
Capsella bursa-pastoris (L.) Medic.
Camelina sativa (L.) Crantz.
Chenopodium album L.
Chenopodium botrys L.
Chenopodium murale L.
Cirsium arvense (L.) Scop.
Echinochloa crusgalli (L.) Beauv.
Lactuca scariola L.
Lactuca scariola var. integrata Gren. & Godr.
Linaria vulgaris Hill.
Linum usitatissimum L.
Melilotus alba Desv.
Melilotus officinalis (L.) Lam.
Martynia louisiana Mill.
Polygonum erectum E.
Polygonum persicaria L.
Polygonum aviculare L.
Polygonum aviculare var. littorale (Link.) Koch.
Pastinaca sativa L.
Phleum pratense L.
Sisymbrium officinale (L.) Scop.
Sisymbrium altissimum L.
Setaria glauca (L.) Beauv.
Setaria viridis (L.) Beauv.
Setaria verticillata (L.) Beauv.
Silene noctiflora L.
Taraxacum erythrospermum Andrz.
Taraxacum officinale Weber.
Trifolium pratense L.
Tanacetum vulgare L.

The Border Areas

The numerous detached groves and the forest fringes bordering the lakes and streams which everywhere break the monotony of the prairie, present an exceptional opportunity for the study of the belts that mark the transition from forest to prairie.

The deep woods, such as those near Elm Crest, in the big loop of the Little Sioux, at Arnold's Park, on the east shores of East Okoboji lake, at the Inn, at Center lake, and in the Hottes lake region, are truly mesophytic; the prairies which occupy the greater part of the land area are just as truly xerophytic; and between them, and forming a transition from one to the other, is a belt in which, on account of the blending of physical conditions, there is a mixture of the two floras. This belt is variable in width. Where the topography changes very abruptly this transition belt is narrow, as at Twin Mounds, and at other points; but where the change is gradual as on the west side of Elm Crest forest, and at other points, the belt is broader and less definite.

The bur oak is the dominant forest type in all these border portions of the groves. Although in various parts of the state this species shows a remarkable power of adaptation to different conditions, in this region it is essentially a xerophyte, of a more or less stunted type, extreme border specimens being sometimes reduced almost to the minimum western form which has received the name *Quercus macrocarpa* var. *depressa*[10] with rough, very corky, irregular twigs, and reduced leaves and acorns. Occasionally *Fraxinus pennsylvanica* var. *lanceolata*, some species of *Cratægus*, and *Prunus americana* occur with the bur oaks. Mingled with these border trees a shrub, *Symphoricarpos occidentalis* is usually quite common.

The herbaceous plants of these open borders are partly those of the prairie, as is shown in columns VII and VIII of the preceding list, and partly forest mesophytes which usually persist in more sheltered nooks and minor depressions. This mixing of forest and prairie floras is clearly due to the blending of the physical conditions which prevail in each type.

Mingled with the prairie species of columns VII and VIII in the open forest borders are certain species which are listed in this paper with the forest plants, but which are most frequent on the border areas. Such are the following:

Apocynum androsæmifolium	Prunus virginiana
Clematis virginiana	Prunus americana
Celastrus scandens	Quercus macrocarpa
Cratægus macracantha	Rudbeckia triloba
Cratægus mollis	Rosa blanda
Cratægus punctata	Rhus glabra
Cratægus ——— sp.?	* Ribes floridum
Erysimum cheiranthoides	Zanthoxyllum americanum
Helianthus lætiflorus	Viburnum lentago

Of the forest plants proper the following were found most frequently in the border areas:

* Acer negundo	Oryzopsis racemosa

[10] This form has been reported by the writer in several papers as *Quercus macrocarpa* var. *olivaeformis*, which is incorrect. The form was first named *Q. obtusiloba* var. *depressa* by Nuttall in "The Genera of North American Plants," 1818, vol. II, p. 215, and was later referred to *macrocarpa* by Englemann in "The Oaks of The United States," in the Transactions of the Academy of Science of St. Louis, vol. III, 1876, p. 111. The name should therefore be written *Quercus macrocarpa* var. *depressa* (Nutt.) Eng. The form is clearly an ecological variety which grades into the type, but it is convenient to retain the name for ecological discussions.

Celtis occidentalis crassifolia
Cryptotænia canadensis
Fraxinus pennsylvanica lanceolata
Geum album
Lappula virginiana
* Populus deltoides
Phryma leptostachya
Psedera quinquefolia
Smilax hispida
* Ulmus americana
* Vitis vulpina

Those marked with an asterisk in both these supplementary border lists are found ordinarily at the more moist borders.

The Flora of the Beaches

The lake beaches are of two types: the sandy or gravelly beaches with a mingling of xerophytic and hydrophytic floras; and the mud beaches with the flora largely hydrophytic.

As already noted the sand beaches frequently blend with sandy prairie. Almost any of the plants given in columns V and VI of the xerophytic list may be found locally well down on the outer portions of the sand beaches. The lacustrine plants proper are however, usually of the swamp type, and mingled with them quite frequently are the weeds listed with the hydrophytes.

The following swamp species, all given in the hydrophytic list, have been collected on the moist sand beaches:

Asclepias incarnata
Amorpha fruticosa
Alopecurus geniculatus
Carex comosa
Carex sychnocephala
Carex vulpinoidea
Cornus amomum
Cornus stolonifera
Cyperus aristatus
Cyperus speciosus
Cyperus strigosus
Eleocharis acicularis
Eleocharis palustris
Eupatorium perfoliatum
Equisetum hyemale robustum
Gerardia tenuifolia
Impatiens biflora
Iris versicolor
Lobelia spicata hirtella
Lycopus americanus
Lycopus lucidus americanus
Lycopus rubellus
Mentha arvensis canadensis
Polygonum lapathifolium
Radicula palustris
Ranunculus cymbalaria
Ranunculus pennsylvanicus
Ranunculus sceleratus
Rumex persicarioides
Salix amygdaloides
Salix cordata
Salix longifolia
Sicyos angulata
Scirpus validus
Silphium perfoliatum
Sium cicutæfolium

Juncus Dudleyi	Spartina Michauxiana
Juncus nodosus	Stachys palustris

To these should be added *Echinocystis lobata, Ribes floridum* and *Sambucus canadensis* of moist thickets and borders, and *Elymus robustus* of moist prairie borders.

II — THE PLANTS OF SWAMPS, LAKES, ETC.

As has been noted the variety of hydrophytic conditions presented in this region makes it of especial interest. The hydrophytic flora varies from that of the plankton and the deep waters of the lakes to that of the moist forest or prairie border. This flora has not been fully investigated, and much work remains to be done, particularly on the plankton and in zonal studies. The writer expected to complete an account of the diatoms of this region for this report, but this was not possible, and the extensive collections taken at all depths will form the basis of a later supplementary report. The algæ also need much more extensive study.

The principal groups of plants are represented as follows:

Subkingdom I. — THALLOPHYTA

Fungi. — The fungi of this group, so far as observed, are all parasitic marsh species, and their habitats are determined by those of their host plants. The most complete list of these species was published by Arthur.[11] The locality is given as Dickinson county. The portion of the list from this locality follows:

Uromyces acuminatus Arth., on *Spartina Michauxiana.*

Puccinia caricis (Schum.) Rab., on *Carex stricta, C. adusta,* and *C. straminea.*

Uropyxis amorphæ (Curt.) Schkr., on *Amorpha fruticosa.*

Æcidium impatientis Schw., on *Impatiens pallida*; also on *I. biflora* by Giddings.

Puccinia phragmites (Schw.) Koern., on *Phragmites communis.*

Puccinia arundinariæ Schw., on *Spartina Michauxiana.*

Puccinia polygoni Pers., on *Polygonum Hartwrightii* and *P. Muhlenbergii.*

Puccinia angustata Peck, on *Scirpus atrovirens.*

Puccinia eleocharis Arth., on *Eleocharis intermedia.*

Puccinia calthæ Link, on *Caltha palustris.*

Puccinia tenue Schw., on *Eupatorium purpureum.*

Hume also reported[12] the following:

Ustilago Arthuri Hume, on *Glyceria grandis.*

11 Bulletin of the Iowa Agricultural College, 1884.

12 See Bibliography.

The following additional species is not uncommon:

Cladosporium typharum Desm., on dead or old leaves of *Typha.*

Diatomaceæ. — A more complete record of the diatoms of this region will be published later. They have heretofore received scant attention. Buchanan reported the following species: [13]

Melosira granulata, Lake Okoboji and Gar lake.

Stephanodiscus niagaræ Ehr., Gar lake.

Tabellaria fenestrata (Lyngb.) Kutz., Gar lake.

Myers had previously given a general report [13] on the diatoms of this region, and referred to the genera *Cocconema, Gomphonema, Fragillaria, Synedra, Odontidium,* and *Stictodiscus.*

Algæ. — In the Proceedings of the Iowa Academy of Sciences, vol. IV, 1897, the writer reported a list of Okoboji algæ, identified by Miss Cavanagh, containing the following species:

Chætophora piciformis (Roth) Ag.

Cladophora glomerata Kg.

Cladophora fracta Kg.

Cladophora fracta gossypina Kg.

The writer has since added *Hydrodictyon utriculatum,* and a number of other species not yet identified.

Buchanan (loc. cit.) reports the following: [13]

Cœlosphærium Keutzingianum Naeg., South Gar lake.

Microcystis (Clathrocystis) æruginosa Kuetz, E. Okoboji lake.

Anabæna circinalis Raben., E. Okoboji lake.

Glœotrichia (Rivularia) pisum Thur., Gar lakes.

Œdogonium Franklinianum Wittr., Gar lake.

Penium closteroides Ralfs., E. Okoboji lake.

Cosmarium undulatum Corda, N. Gar lake.

Volvox globator (L.) Ehrenb., Lower Gar lake.

Subkingdom II. — BRYOPHYTA

The following representatives of this group were formerly quite common, but have become rare:

Hypnum fluitans L. In ponds.

Ricciocarpa natans (L.) Corda. Ponds.

Riccia fluitans L. E. Okoboji lake.

The *Pteridophyta* are also represented by but one species, and the *Spermatophyta* again form the conspicuous feature of this flora. Frequently the latter form greater or lesser beds which are more or less widely separated, with a few or no specimens scattered between them. These plants are thus often found in but few localities, but may there be very abundant.

In the appended list of vascular plants the following symbols are employed:

1. — The Roman numerals at the heads of the columns mark groups of localities as follows:

I. — Miller's Bay and Emerson's Bay.

[13] See Bibliography.

II. — East and West Okoboji lakes near the strait joining them.

III. — The shores and border swamps around East and West Okoboji lakes.

IV. — The Gar lakes.

V. — The north end of East Okoboji lake.

VI. — Kettle-holes and bogs between West Okoboji lake and the Little Sioux river.

VII. — Kettle-holes between East and West Okoboji lakes.

VIII. — The smaller lakes northwest of Spirit lake, and the shores of the latter.

Localities I and II are comparatively deep water places with constant beds of submersed or partly floating plants; columns III, VI and VII represent the shallower ponds and border swamps; columns IV and V are also representative of rather deep water, but shallower than I; VIII represents a combination of shallow waters and border swamps.

2. — The letters in the first column indicate the usual habitat of the species as follows:

m. — Lakes and deeper ponds.

n. — Borders of lakes and kettle-holes.

o. — Hillside bogs and seepy places.

p. — Higher, but moist grounds, moist borders of thickets, etc.

3. — The numbers in the columns indicate roughly the relative abundance of the species as before. This varies very much with the seasons. During wet seasons there is a relatively smaller number of border swamp species, and an increase in the number of deeper water forms. The latter, however, are less inclined to flower and fruit during such seasons. During dry seasons the border plants cover larger areas, and there is a diminution in the number of deep water forms, but an increase in the relative number of flowers and fruits.

		I	II	III	IV	V	VI	VII	VIII
Subkingdom III PTERIDOPHYTA									
Family *Equisetaceæ*									
Equisetum hyemale robustum (A. Br.) A. A. Eaton	n			4					
Subkingdom IV SPERMATOPHYTA									
Subclass MONOCOTYLEDONEÆ									
Family *Typhaceæ*									
Typha latifolia L.	n			3					3
Family *Sparganiaceæ*									
Sparganium americanum androcladum (Eng.) F. & E.	n			4					
Sparganium eurycarpum Engelm.	n			3			3	3	3
Sparganium simplex Huds.	n			4				4	
Family *Najadaceæ*									
Potamogeton americanus C. & S.	m	4				4			4
Potamogeton amplifolius Tuck.	m	4	4			4			4
Potamogeton dimorphus Raf.	m					5			

		I	II	III	IV	V	VI	VII	VIII
Potamogeton epihydrus Raf.	m			5					
Potamogeton Friesii Rupr.	m		4			4			
Potamogeton foliosus Raf.	m	3	3						
Potamogeton heterophyllus Schreb.	n			5					
Potamogeton natans L.	m	4		3		4			3
Potamogeton pectinatus L.	m	3	3	3	3	3			
Potamogeton prælongus Wulf.	m	4	3			4			4
Potamogeton pusillus L.	m		4			4			
Potamogeton Richardsonii (Benn.) Ryd.	m	3	3		3	3			3
Potamogeton zosterifolius Schum.	m	3	3	3		3			
Zanichellia palustris L.	m		4			4			4
Najas flexilis (Willd.) R. & S.	m	3	3	3	4	3			3
Family *Alismaceæ*									
Sagittaria arifolia Nutt.	n			3				4	3
Sagittaria latifolia Willd.	n			3		2	4		3
Echinodorus cordifolius (L.) Gr.	n			4					
Alisma plantago-aquatica L.	n			3			3	3	3
Family *Hydrocharitaceæ*									
Elodea canadensis Michx.	m	2	2		2	3			3
Elodea iowensis Wylie	m					3			
Vallisneria spiralis L.	m	3	2		3	2			3
Family *Gramineæ*									
Panicum dichtotomum villosum Vasey	n						4		
Panicum Gattingeri Nash.	n			4			4		
Echinochloa crus-galli (L.) Beauv.	n			4		4		4	
Leersia oryzoides (L.) Sw.	n			4		4			
Phalaris arundinacea L.	n			4			4		
Alopecurus geniculatus L.	n			4	4			4	
Agrostis alba L.	n			4				4	
Calamagrostis canadensis (Michx.) Beauv.	n			2		3		3	
Sphenopholis pallens (Spreng.) Scrib.	n			5					
Spartina Michauxiana Hitch.	n			3	3		3	3	3
Beckmannia erucæformis (L.) Host.	n			5					
Phragmites communis Trin.	n			3		4			
Poa triflora Gilib.	n			3					
Glyceria nervata (Willd.) Trin.	n			3					
Glyceria grandis Wats.	n			3		4			
Elymus robustus Scrib. & J. G. S.	n			4					
Family *Cyperaceæ*									
Cyperus aristatus Rottb.	n			4		3			3
Cyperus erythrorhizos Muhl.	n			4					

		I	II	III	IV	V	VI	VII	VIII
Cyperus rivularis Kunth	n			3		3		4	
Cyperus Schweinitzii Torr.	n			4		3			
Cyperus speciosus L.	n					3		4	3
Cyperus strigosus L.	n			3			4	4	3
Eleocharis acicularis (L.) R. & S.	n			3			3	3	3
Eleocharis ovata (Roth.) R. & S.	n			4			4		
Eleocharis palustris (L.) R. & S.	n			3				3	3
Eleocharis palustris vigens Bail.	n			4					
Eleocharis Wolfii Gray	n								4
Scirpus atrovirens Muhl.	n			3		3		3	3
Scirpus fluviatilis (Torr.) Gray	n			3		2		4	
Scirpus validus Vahl.	n	3		3	3		3	3	2
Carex Bebbii Olney	n					3			3
Carex comosa Boott	n			5					
Carex cristata Schw.	n			3					
Carex fœna perplexa Bail.	n			4					
Carex hystericina Muhl.	n			4		4			4
Carex Sartwellii Dew.	n							5	
Carex stipata Muhl.	n			5					
Carex sychnocephala Carey	n			5		5	5		
Carex tribuloides Wahl.	n			4					
Carex trichocarpa aristata (R. Br.) Bail.	n				4				
Carex vulpinoidea Michx.	n			3			3	3	3
Family *Araceæ*									
Acorus calamus L.	n			4					
Family *Lemnaceæ*									
Spirodela polyrhiza (L.) Schleid.	n			3					
Lemna trisulca L.	n			3	3	3		3	
Wolffia punctata Gris.	n			5					
Family *Pontederiaceæ*									
Heteranthera dubia (Jacq.) MacM.	m			4	3	3			3
Family *Juncaceæ*									
Juncus bufonius L.	n			5					
Juncus nodosus L.	n								4
Juncus tenuis Willd.	n			3			3		3
Juncus Torreyi Cov.	n			3			4		
Juncus Vaseyi Engelm.	n						4		
Family *Liliaceæ*									
Lilium canadense L.	n			5					
Family *Iridaceæ*									
Iris versicolor L.	n			3					
Family *Orchidaceæ*									
Habenaria leucophæa (Nutt.) Gray	o						4		

		I	II	III	IV	V	VI	VII	VIII
Subclass DICOTYLEDONEÆ									
Family *Salicaceæ*									
Salix amygdaloides Anders.	n			3					
Salix cordata Muhl.	n			4					
Salix discolor Muhl.	o			4	4			4	
Salix longifolia Muhl.	n			3					
Salix missouriensis Bebb	n			4					
Family *Urticaceæ*									
Urtica gracilis Ait.	n			4				4	
Family *Polygonaceæ*									
Rumex brittanica L.	n						3	3	
Rumex persicarioides L.	n			2	4			3	3
Polygonum acre H. B. K.	n			2	3				3
Polygonum amphibium L.	n			3				4	
Polygonum hydropiperoides Michx.	n			4					
Polygonum lapathifolium L.	n			2	3	4	3	3	3
Polygonum Muhlenbergii (Meisn.) Wats.	n			4				4	
Polygonum pennsylvanicum L.	n			3				3	
Family *Amaranthaceæ*									
Acnida tuberculata subnuda Wats.	n			3			3		
Family *Caryophyllaceæ*									
Stellaria longifolia Muhl.	p			5					
Family *Ceratophyllaceæ*									
Ceratophyllum demersum L.	m	1	1	3	1	2			2
Family *Nymphæaceæ*									
Nymphæa advena Ait.	m				5				5
Castalia tuberosa (Paine) Greene	m				5				
Family *Ranunculaceæ*									
Ranunculus aquatilis capillaceous DC.	m			5					
Ranunculus circinatus Sibth.	m	3		3					
Ranunculus cymbalaria Pursh	n			3				3	
Ranunculus delphinifolius Torr.	n			5					
Ranunculus pennsylvanicus L. f.	n			3	3				
Ranunculus septentrionalis Poir.	n						4	4	
Ranunculus sceleratus L.	n			3					3
Anemone canadensis L.	n			4					
Caltha palustris L.	n			4					
Family *Cruciferæ*									
Cardamine bulbosa (Schreb.) B. S. P.	n			4					
Radicula palustris (L.) Moench	n			3	3		3		
Radicula palustris hispida (Desv.)				3			3		
Rob.	n			3			3		
Family *Crassulaceæ*									

		I	II	III	IV	V	VI	VII	VIII
Penthorum sedoides L.	n			3					3
Family *Saxifragaceæ*									
Parnassia caroliniana Michx.	o			5					
Ribes floridum L'Her.	p				4				4
Family *Rosaceæ*									
Spiræa salicifolia L.	n							5	
Potentilla monspeliensis L.	n			4			4		
Potentilla Nicollettii (S. Wats.) Sheld.	n			4					
Potentilla paradoxa Nutt.	n			3					
Family *Leguminosæ*									
Amorpha fruticosa L.	p			4					
Lathyrus palustris L.	n			4					
Family *Callitrichaceæ*									
Callitriche palustris L.	m				5				
Family *Balsaminaceæ*									
Impatiens biflora Walt.	n			4					
Impatiens pallida Walt.	n			3				4	
Family *Hypericaceæ*									
Hypericum majus (Gray) Britt.	n						4		
Hypericum cistifolium Lam.	n						4		
Hypericum virginicum L.	n			4					
Family *Lythraceæ*									
Lythrum alatum Pursh	n			4	4				
Family *Onagraceæ*									
Ludvigia polycarpa S. & P.	n			4					
Epilobium adenocaulon Haussk.	n			3				3	3
Family *Haloragidaceæ*									
Myriophyllum spicatum L.	m	1	1	3	2	2			2
Family *Umbelliferæ*									
Cicuta bulbifera L.	n			4					
Cicuta maculata L.	n			3					
Sium cicutæfolium Schranck.	n			3	4		3		
Family *Cornaceæ*									
Cornus amomum Mill.	p			4	4				
Cornus stolonifera Michx.	p			4					
Family Primulaceæ									
Steironema ciliatum (L.) Raf.	n			3					
Steironema quadrifolium (Sims.) Hitch.	n			3			3		
Family *Apocynaceæ*									
Apocynum cannabinum hypericifolium (Ait.) Gray	n			3					
Family *Asclepiadaceæ*									
Asclepias incarnata L.	n			4					4

		I	II	III	IV	V	VI	VII	VIII
Asclepias incarnata pulchra (Ehr.) Pr.	n			4				4	
Family *Convolvulaceæ*									
Cuscuta cephalanthi Eng. (on *Salix*)	n							4	
Family *Verbenaceæ*									
Verbena hastata L.	n			3					3
Family *Labiatæ*									
Teucrium occidentale Gray	n			2					3
Scutellaria galericulata L.	n			3			3		
Scutellaria lateriflora L.	n			4					
Physostegia parviflora Nutt.	p			5					
Stachys palustris L.	n			3					
Lycopus americanus Muhl.	n			3		3		3	3
Lycopus lucidus americanus Gray	n			3		3			3
Lycopus rubellus Moench.	n			5				4	
Lycopus virginicus L.	n			4					
Mentha arvensis canadensis (L.) Briq.	n			3					3
Family *Scrophulariaceæ*									
Mimulus ringens L.	n			4				4	
Ilysanthes dubia (L.) Barnh.	n			5					
Veronica anagallis-aquatica L.	n							4	
Gerardia tenuifolia Vahl	n			3			4		4
Gerardia tenuifolia macrophylla Benth.	n							5	
Pedicularis lanceolata Michx.	n			4					
Family *Lentibulariaceæ*									
Utricularia vulgaris americana Gray	n						4		
Family *Rubiaceæ*									
Galium Claytoni Michx.	n			4					
Galium tinctorium L.	n			3					
Galium trifidum L.	n			4					
Galium triflorum Michx.	n			4					
Family *Campanulaceæ*									
Campanula aparinoides Pursh	n			4					
Family *Lobeliaceæ*									
Lobelia siphilitica L.	o			3			3	3	
Lobelia spicata Lam.	n			4					
Lobelia spicata hirtella Gray	n			3			4		4
Family *Compositæ*									
Vernonia fasciculata Michx.	n			3					
Eupatorium perfoliatum L.	n			3	3			4	3
Eupatorium purpureum L.	n			4					4
Eupatorium purpureum maculatum (L.) Darl.	n			4					

		I	II	III	IV	V	VI	VII	VIII
Solidago canadensis L.	p			4					
Solidago Riddellii Frank	n						4		
Solidago serotina gigantea (Ait.) Gray	p			4					
Boltonia asteroides (L.) L'Her.	n			3			1		
Aster puniceus lucidulus Gray	n			5					
Aster umbellatus Mill.	o			4			4		
Erigeron philadelphicus L.	p			4					
Eclipta alba (L.) Hassk.	n			4					
Silphium perfoliatum L.	n						4		
Ambrosia trifida L.	n						3	2	
Rudbeckia laciniata L.	p			4					
Helianthus grosserratus Mart.	n						3	3	
Bidens Beckii Torr.	m	3				4			
Bidens cernua L.	n			3					
Bidens frondosa L.	n			4					
Bidens vulgata puberula (Wieg.) Greene	n			3				3	3
Helenium autumnale L.	n			4			4		
Artemisia biennis Willd.	n			4			4		
Senecio aureus L.	n							5	
Senecio palustris (L.) Hook.	n			5					
Cirsium muticum Michx.	n			5					
Prenanthes racemosa Michx.	n						4		

In addition to their more characteristic flora the border swamps also sometimes contain plants belonging ordinarily to other habitats. In such cases the plants appear in small numbers, and not infrequently on hummocks which offer limited but fairly well drained stations for their growth. The following species were collected by the writer in such places:

Prairie plants

Allium canadense
Ambrosia psilostachya
Aster lævis
Elymus virginicus
Erigeron philadelphicus
Hordeum jubatum
Lespedeza leptostachya
Panicum capillare
Oxalis stricta
Pycanthemum flexuosum
Pycanthemum virginianum
Sporobolus heterolepis
Thalictrum dasycarpum
Thaspium aureum
Zizia aurea

Forest plants

Agrimonia striata
Chenopodium hybridum
Ribes floridum
Stellaria longifolia

Introduced weeds

Chenopodium album
Chenopodium urbicum
Polygonum aviculare

III — THE FOREST FLORA

The more heavily forested areas present the characteristics of the wooded sections of the eastern part of the state, with this difference that fewer species appear here, these groves presenting in fact an attenuation of the southeasterly forest flora.

The more open woods and the borders of the groves have already received attention. The deeper woods offer little that is unique. The dominant flora is of the usual type, and chlorophylless Thallophytes, such as slimemoulds, fungi, and with them the lichens, appear in larger numbers. The mycological flora is best developed in the woods at Elm Crest, near the Inn, and at Center lake, and also in the deep woods of the ''big loop'' of the Little Sioux river.

A brief report on the flora of the forested areas follows:

Subkingdom I. — THALLOPHYTA

Fungi. — Mr. L. A. Giddings prepared a list of the fungi and slimemoulds, collected largely by himself, for this paper. The list consists largely of forest forms, and is here presented as originally prepared, but without the prairie, swamp, and introduced species, which were transferred to their respective lists, and with the addition of several species from the collections of President Macbride and the writer. The latter are marked with an asterisk. Most of the identifications in the entire list were verified by President Macbride.

Class MYXOMYCETES

Subclass EXOSPOREÆ

Ceratiomyxa fructiculosa (Muell.) Macbr. — Elm Crest woods and Center lake. On decaying wood.

Ceratiomyxa porioides (Alb. & Schw.) Schr. — Elm Crest; on decaying wood.

Subclass MYXOGASTRES

Order PHYSARALES

Badhamia panicea (Fr.) Rost. — Woods south of Miller's Bay; on old bark of *Populus.*

Craterium minimum B. & C. — Elm Crest; on decaying wood.

Diderma crustaceum Pk. — Arnold's Park; collected but once; on stems of plants.

Fuligo ovata (Schaeff.) Macbr. — Common everywhere; on old stumps at border of woods.

Fuligo violacea Per. — Not so common as preceding; old stumps at border of woods.

Mucilago spongiosa (Leyss.) Morgan. — Common; on stems of plants and grass blades.

Physarella oblonga (B. & C.) Morgan — Laboratory grounds and Little Sioux river; on decaying wood.

Physarum contextum Per. — Little Sioux river; collected but once; decaying wood.

Physarum leucopus Link. — Miller's Bay; common; on decaying leaves in wet places.

Physarum nefroideum Rost. — Common; chiefly on decaying bark.

Tilmadoche viridis (Bull.) Sacc. — Woods at Estherville; on decaying wood.

Order STEMONITALES

Comatricha stemonitis (Scop.) Shel. — Elm Crest; on decaying wood; a large collection was made.

Stemonitis fenestrata Rex. — Center lake; on decaying wood; large collection.

Stemonitis maxima Schw. — Center lake; on decaying wood; large collection.

Stemonitis Morgani Pk. — Center lake; on decaying wood; small collection.

Stemonitis Smithii Macbr. — Miller's Bay; on decaying wood; several collections.

Order CRIBRARIALES

Dictydium cancellatum purpureum Macbr. — Elm Crest; on decaying wood; found but once.

Reticularia lycoperdon Bull. — Arnold's Park; on decaying wood; one collection.

Tubifera ferruginosa (Batsch) Macbr. — Miller's Bay; on decaying wood; found but once.

Order LYCOGALALES

Lycogala epidendrum (Buxb.) Fr. — Inn woods; Center lake; Little Sioux river; on decaying wood.

Order TRICHIALES

Arcyria cinerea (Bull.) Per. — Little Sioux river; decaying wood; one collection.

Arcyria denudata (L.) Sheld. — Common everywhere; on decaying wood.

Arcyria nutans (Bull.) Grev. — Miller's Bay; on decaying wood; small collection.

Hemitrichia clavata (Pers.) Rost. — Common; decaying wood.

Hemitrichia vesparium (Batsch) Macbr. — Estherville, Little Sioux river, Inn; on decaying wood.

Trichia persimilis Karst. — Miller's Bay; one collection; on an old stump.

Trichia varia (Pers.) Rost. — Estherville, Little Sioux river, Center lake; on decaying wood.

Class PHYCOMYCETES

Order PERONOSPORALES

Plasmopara viticola (B. & C.) Berl. — Little Sioux river; on *Vitis vulpina* L.

Class ASCOMYCETES

Order EXOASCALES

Exoascus pruni (Fckl.) Tul. — Miller's Bay; on cultivated and wild plums.

Order HELVELLALES

Helvella crispa (Scop.) Fr. — Estherville; on the ground.

Helvella elastica Bull. — Elm Crest; on the ground.

Helvella lacunosa Afzel. — Estherville; on the ground.

Leotia stipitata (Bosc.) Schr. — Estherville; on the ground.

Order PEZIZALES

Acetabula acetabulum (L.) Fckl. — Elm Crest; on the ground.

Acetabula sulcatum (Pers.) Fckl. — Elm Crest; on the ground.

Chlorosplenium versiforme (Pers.) De Not. — Miller's Bay; on old stump.

Ciboria sulphurella (E. & E.) Rehm. — Miller's Bay; on an old stump.

Helotium Friesii (Weinn.) Sacc. — Inn woods; on decaying leaves.

Lachnea hemispherica (Schaeff.) Gill. — Elm Crest; Estherville; on the ground.

Lachnea paludosa (Boud.) Sacc. — Center lake; on the ground.

Lachnea scutellata (L.) Gill. — Little Sioux river, Center lake, Miller's Bay; on wood.

Peziza badia Pers. — Elm Crest, Estherville, Center lake; on the ground.

Phialea fructigena (Bull.) Gill. — Little Sioux river; on acorns.

Pyronema melaloma (Fr.) Sacc. — Bluff Point; on burnt ground.

Sarcosypha floccosa (Schw.) Sacc. — Center lake; on decaying twigs in leaves.

Sarcosypha occidentalis (Schw.) Sacc. — Center lake; on decaying twigs in leaves.

Order PHACIDIALES

Rhytisma acerinum (Per.) Fr. — Eagle Point; on leaves of *Acer saccharinum* L.

Order PERISPORIALES

Erysiphe communis (Wallr.) Fr. — Arnold's Park; on *Viola sp.*

Erysiphe cichoracearum DC. — Pratt's lake; on *Hydrophyllum virginianum* L.

Podosphæra oxycanthæ (DC.) D. By. — Miller's Bay; on *Prunus virginiana* L.

Order HYPOCREALES

* *Claviceps fragilis.* — West Okoboji woods.

Order DOTHIDIALES

Plowrightia morbosa (Schw.) Sacc. — Common; on wild plum; also found on *Amelanchier canadense* by Prof. Macbride.

Order SPHÆRIALES

Amphisphæria confertissima E. & E. — West Okoboji woods.

Daldinia concentrica Bolt. — Common; on stumps and decaying wood.

Hypoxolon perforatum Schw. — Common; on dead wood.
Lasiosphæria ovina Pers. — Little Sioux river; on dead wood.
* *Nummularia Bulliardi* Tiel. — Center lake woods.
* *Xylaria grandis* Pk. — West Okoboji woods.
Xylaria polymorpha Pers. — Common; around decaying stumps.

* Order MONILIALES

* *Hormodendrum corticale* E. & E. — West Okoboji woods.

Class BASIDIOMYCETES

Subclass PROTOBASIDIOMYCETES

Order TREMELLALES

Tremella frondosa Fr. — Elm Crest; on decaying wood.
Tremella mycetophila Pk. — Elm Crest; on *Collybia dryophila* Bull.

Order UREDINALES

Puccinia asteris Duby. — Miller's Bay; on *Aster cordifolius* L.
Puccinia fraxinata (Lk.) Arthur. — Miller's Bay; on green ash.

Subclass AUTOBASIDIOMYCETES

Order AGARICALES

Family *Thelephoraceæ*

Craterellus cantharellus (Schw.) Fr. — Elm Crest; on the ground.
Hymenochæte rubiginosa (Schr.) Lev. — Elm Crest; on decaying bark and wood.
Stereum frustulosum (Pers.) Fr. — Miller's Bay; on old stumps.
Stereum hirsutum (Willd.) Pers. — Elm Crest; on old stumps.
Stereum versicolor (Sw.) Fr. — Elm Crest, Center lake; on old stumps.
* *Thelephora Schweinitzii* Peck. — West Okoboji woods.
* *Thelephora palmata* (Scop.) Fr. — Elm Crest.

Family *Clavariaceæ*

* *Clavaria amethystina* Bull. — West Okoboji woods.
Clavaria botrytes Pers. — Elm Crest; on decaying wood.
Clavaria coralloides L. — Elm Crest; on the ground.
Clavaria cristata Pers. — Elm Crest; on the ground.
* *Pterula densissima* B. & C. — Estherville.
Sparassia crispa Fr. — Elm Crest; on the ground.

Family *Boletaceæ*

Boletinus porosus (Berk.) Pk. — Elm Crest; on the ground.
Boletus versipellis Fr. — Miller's Bay; on the ground.

Family *Polyporaceæ*

Dædalea confragosa (Bolton) Pers. — Common on willow.
Dædalea unicolor Fr.— Elm Crest, Center lake; on stumps.
Favolus canadensis Klotsch. — Common on decaying branches.
Fomes applanatus (Pers.) Wallr. — Elm Crest; on decaying wood.
* *Fomes dryophilus* (Berk.) — West Okoboji woods; rare.

Fomes fulvus (Scop.) Gill. — Common everywhere; on plum.
Fomes fraxinophilus Fr. — Miller's Bay; on green ash.
Fomes igniarius Fr. — Elm Crest; on oaks.
Fomes leucophœus Mont. — Elm Crest, Center lake; on standing trees.
* *Fomes nigricans* Fr. — West Okoboji woods.
Polyporus adustus Fr. — Elm Crest, Little Sioux river; on decaying wood.
Polyporus brumalis Fr. — Elm Crest, Little Sioux river; on decaying branches.
Polyporus cinnabarinus Schw. — Center lake; on decaying wood.
* *Polyporus flavovirens* B. & Rav. — West Okoboji lake; rare.
Polyporus gilvus Schw. — Center lake; on dead wood.
* *Polyporus gilvus var. scruposus* (Fr.) — West Okoboji woods.
Polyporus picipes Fr. — Little Sioux river; on decaying branches.
Polyporus squamosus Fr. — Little Sioux river; on living willow.
Polyporus sulphureus Fr. — Center lake; on dead wood.
Polystictus hirsutus Fr. — Elm Crest, Center lake; on decaying wood.
Polystictus versicolor Fr. — Common everywhere; on decaying wood.
Solenia ochracea Hoffm. — Little Sioux river; on decaying wood.
* *Trametes Peckii* Kal. — Little Sioux river; rare.

Family *Hydnaceæ*

* *Hydnum ochraceum* Pers. — West Okoboji woods.
Irpex carneus Fr. — Elm Crest; on decaying wood.
Irpex lacteus Fr. — Elm Crest; on decaying wood.

Family *Agaricaceæ*

Agaricus campestris L. — Elm Crest.
Amanitopsis vaginata Bull. — Common everywhere.
Armillaria mellea Vahl. — Little Sioux river.
Clitocybe candicans Fr. — Elm Crest.
Collybia dryophila Bull. — Elm Crest.
Collybia platyphylla Fr. — Elm Crest.
Collybia radicata Rehl. — Elm Crest, Center lake.
Coprinus atramentarius Fr. — Elm Crest, Center lake, Little Sioux river.
Coprinus comatus Fr. — Elm Crest.
Coprinus micaceus Fr. — Center Lake, Elm Crest.
Crepidotus versutus Pk. — Elm Crest.
Galera tenera Schaeff. — Elm Crest.
* *Hebeloma crustulineforme* Bull. — West Okoboji woods.
Hygrophorus miniatus Fr. — Arnold's Park, Elm Crest, Center lake.
* *Hygrophorus pratensis* (Pers.) Fr. — West Okoboji woods.
* *Hypholoma Candolleanum* Fr. — West Okoboji woods.
* *Lentinus tigrinus* (Bull.) — West Okoboji woods.
Lepiota acutesquamosa Wein. — Inn woods.
* *Lepiota cristata* A. & S. — West Okoboji woods.
Marasmius campanulata Pk. — Elm Crest.
Marasmius rotula Fr. — Elm Crest.

Marasmius siccus Schw. — Elm Crest.
Mycens pura Pers. — Elm Crest, Arnold's Park.
Panus dorsalis Bosc. — Center lake.
Panus rudis Fr. — Elm Crest.
Panus stypticus Fr. — Common on old stumps.
* *Panæolus campanulatus* L. — Center lake woods.
Panæolus solidipes Pk. — Elm Crest, Center lake.
Pluteus cervinus Schaeff. — Center lake, Elm Crest.
Psathyrella disseminata Pers. — Inn woods.
Russula delica Fr. — Elm Crest.
Russula emetica Fr. — Center lake, Elm Crest, Arnold's Park.
Russula roseipes (Secr.) Bres. — Elm Crest, Center lake.
Schizophyllum commune Fr. — Common everywhere on decaying branches.
Stropharia stercoraria Fr. — Elm Crest.

Order PHALLALES

Phallus impudicus L. — Center lake, Little Sioux river; around old stumps.

Order SCLERODERMATALES

Scleroderma vulgare Fr. — Elm Crest.

Order NIDULARIALES

Crucibulum vulgare Tul. — Inn woods, Little Sioux river.
Cyathus striatus Hoffm. — Inn woods.

Order LYCOPERDALES

Bovista pila B. & C. — Elm Crest.
Bovista plumbea Pers. — Miller's Bay.
Calvatia gigantea Batsch. — Little Sioux river.
Geaster limbatus Fr. — Estherville, Center lake.
Geaster saccatus Fr. — Center lake, Elm Crest.
* *Lycoperdon atropurpureum* — West Okoboji woods.
Lycoperdon gemmatum Batsch. — Miller's Bay.
* *Lycoperdon molle* Pers. — West Okoboji woods.
Lycoperdon pedicellatum Pk. — Miller's Bay.
Lycoperdon pulcherrimum B. & C. — Center lake.
Lycoperdon pyriforme Schaeff. — Common everywhere on decaying wood.
Mycenastrum spinulosum Pk. — Miller's Bay, head of West Okoboji lake.
* *Secotium Warnei* Pk. — Spirit Lake and West Okoboji woods.

The following additional species of fungi are reported by Arthur (loc. cit.):

Æcidium phrymæ Halst., on *Phryma leptostachya.*

Uromyces terebinthi (DC) Wint., on *Rhus toxicodendron.* (Reported as U. toxicodendri.)

No doubt many species will be added to this, as well as to other lists in this paper. The appearance of the less persistent fungi is so uncertain, and so dependent upon rainfall, that favorable seasons should add many species to the list.

Lichens. — Most of the lichens of this region are restricted to trees. A

few species are found on bowlders, and a still smaller number on earth. The distribution of the species growing on trees is especially interesting. On both the east and west sides of the larger lakes lichens are found chiefly on the sides of the trunks of trees which face the lake. Apparently this peculiarity of distribution is related to moisture rising from the lakes, and these lichens seem to agree with those of the vicinity of Minneapolis described by Fink,[15] who states that "most species of lichens here are disposed to confine themselves to moist situations, as about the bodies of water mentioned above, in heavy woods, or when in dry places near the ground." However, a closer study of the lichens of the region shows that they are usually equally abundant on the *outside* of the groves bordering the lakes, and this is true of the west side of the groves on the west side of the lakes in situations which are usually quite xerophytic. Moreover on both native and planted trees with a north exposure the *north* side of the trunk is likely to be covered with lichens, and in openings in the woods all the trees facing the opening are likely to have lichens on the exposed side. This suggests that light rather than moisture determines the distribution of the lichens in our region. It is probably for the same reason that they do not ascend higher on the trunks of trees where the crowns cut off light.

In recent years there has been a marked reduction in the number of lichens in some of the groves, and in the more striking of these cases it seemed to have followed the pasturing of the groves.

In his paper on Iowa lichens Fink (see Bibliography) reported a number of species collected by Professor Arthur in our region. The species so reported are marked with an asterisk in the following list; the specific locality and habitat references are based on the writer's collections.

LICHENES

* Opegrapha varia (Pers.) Fr. — Inn woods, on *Quercus macrocarpa* and *Juniperus virginiana.*

Opegrapha demissa Tuck. — Inn woods, on *Tilia americana.*

Graphis scripta (L.) Ach. — Inn woods, on *Acer saccharum.*

Graphis scripta var. serpentina (Ach.) Nyl. — Woods north of the Inn, on *Tilia americana.*

* Lecidea enteroleuca Fr. — Near Inn, on old bark.

* Lecidea enteroleuca var. theiophaca Tuck. — Reported by Fink.

* Bacidia fuscorubella (Hoffm.) Arn. — Reported by Fink as *Biatora.*

Buellia parasema (Ach.) Koerb. — On *Tilia americana* near the Inn, and *Quercus macrocarpa* at Spirit Lake.

* Buellia myriocarpa (Lam. & DC.) Mudd. — Near the Inn, on *Acer saccharum* and *Juniperus virginiana.*

* Psora decipiens (Ehrh.) Hoffm. — Calcareous earth. Reported by Fink as *Biatora.*

Cladonia cristatella Tuck. — At Estherville, on old stump.

Cladonia mitrula Tuck. — At Estherville, on earth.

* Cladonia gracilis (L.) Willd. — On earth at Estherville (Fink). On *Juniperus virginiana* at the Inn.

15 Minnesota Botanical Studies, Bulletin no. 9, 1897, particularly p. 705.

Cladonia fimbriata (L.) Hoffm., var. — Arnold's Park on old stump.
Cladonia pulchella Schw. — On old bur oak stump near the Inn.
Peltigera canina (L.) Hoffm. — On banks and steep slopes near Elm Crest and at Estherville; not common.
Lecanora subfusca (L.) Ach. — On bark of trees.
Parmelia perforata (Wulf.) Ach. — Near the Inn on *Quercus macrocarpa, Tilia americana* and *Juniperus virginiana.*
* Parmelia cetrata Ach. — Trees, Estherville (Cratty).
* Parmelia crinita Ach. — Reported by Fink. Trees.
* Parmelia Borreri Turn. — Reported by Fink. Trees.
* Parmelia Borreri var. rudecta Tuck. Reported by Fink. Trees.
* Parmelia olivacea (L.) Ach. — Reported by Fink. Trees.
* Parmelia caperata (L.) Ach. — On *Populus tremuloides* at Arnold's Park; Estherville (Cratty); on old fence, Little Sioux.
* Parmelia conspersa (Ehrh.) Ach. — Estherville (Fink).
* Ramalina calicaris (L.) Fr. — On *Quercus macrocarpa, Acer saccharum* and other trees near the Inn; on *Quercus macrocarpa* at Spirit Lake and Estherville.
Ramalina calicaris var. fraxinea (L.) Fr. — On trees near the Inn; less common.
Placodium aurantiacum (Light.) Hepp. — Common on *Quercus macrocarpa, Tilia americana, Acer saccharum,* etc., near the Inn, and on the first two at Spirit Lake.
Placodium cerinum (Hoffm.) Hepp. — On *Quercus macrocarpa, Juniperus virginiana,* etc., near the Inn; also at Estherville.
* Teloschistes chrysopthalmus (L.) Th. — Widely distributed in the lake region on *Quercus macrocarpa*; also on *Acer saccharum* and *Tilia americana.*
* Teloschistes polycarpus (Hoffm.) Tuck. — Reported by Fink. Dead trees.
* Teloschistes lychneus (Ach.) Tuck. — Widely distributed in the lake region on *Quercus macrocarpa, Tilia americana, Acer saccharum,* etc.
Teloschistes concolor (Dicks.) Tuck. — On *Populus tremuloides* at Arnold's Park, and on *Quercus macrocarpa* at Spirit Lake.
Teloschistes parietinus (L.) Norm. — On *Tilia americana, Acer saccharum,* etc., near the Inn, and at Estherville.
* Physcia stellaris (L.) Nyl. — The most common lichen in this territory. On *Quercus macrocarpa, Tilia americana, Juniperus virginiana, Acer saccharum,* etc., wherever these species occur.
* Physcia adglutinata (Floerk.) Nyl. — Also widely distributed with the preceding, on the same species of trees.
* Dermatocarpon hepaticum (Ach.) Th. — Reported as *Endocarpon,* "on calcareous earth," by Fink.
Endocarpon pusillum Hedw. — On calcareous bowlder in woods. Arnold's Park.

Subkingdom II BRYOPHYTA

Mosses are not abundant. Two species, collected by the writer, were reported by Savage (see Bibliography):

Funaria hygrometrica Sibth. — Woods at Spirit Lake.

Amblystegium riparium L. — On logs in damp woods, at Spirit Lake.

The following additional species were identified by Miss Cavanagh:

Mnium cuspidatum (L.) Ley.

Leskea polycarpa Ehrh. — On bases of trees.

The vascular plants which have been definitely identified are presented in the list which follows. The following symbols are employed in the table:

The Roman numerals mark localities as follows:

I. — Woods of the Elm Crest peninsula.

II. — The narrower wooded borders along the west side of West Okoboji lake.

III. — The woods at Arnold's Park.

IV. — The forest on the southeast side of East Okoboji lake.

V. — The forest border between East and West Okoboji lakes.

VI. — Center lake woods.

VII. — Woods around Spirit Lake.

VIII. — Woods along the Little Sioux river.

IX. — Woods west of Estherville.

The letters in the first column represent the following habitats:

a. — Deep woods.

b. — Open woods and borders.

c. — Moist borders.

i. — Introduced.

The numbers in the columns indicate abundance, and correspond to those used in the preceding tables.

		I	II	III	IV	V	VI	VII	VIII	IX
Subkingdom III—PTERIDOPHYTA										
Family *Polypodiaceæ*										
Adiantum pedatum L.	a									4
Asplenium filix-fœmina (L.) Bernh.	a				4					3
Cystopteris fragilis (L.) Bernh.	a	4								
Family *Osmundaceæ*										
Osmunda Claytoniana L.	a									4
Family *Ophioglossaceæ*										
Botrychium virginianum (L.) Sw.	a	5								5
Family *Equisetaceæ*										
Equisetum hyemale robustum (A. Br.) A. A. Eaton	c			4						
Subkingdom IV — SPERMATOPHYTA										
Class I. GYMNOSPERMÆ										
Family *Pinaceæ*										
Juniperus virginiana L.	a	4				5				

		I	II	III	IV	V	VI	VII	VIII	IX
Subclass I. MONOCOTYLEDONEÆ										
Family *Gramineæ*										
Panicum huachuchæ Ashe.	b	4								
Leersia virginica Willd.	b	3		3						
Oryzopsis racemosa (Sm.) Rick.	a			3						
Muhlenbergia sobolifera (Muhl.) Trin.	a		4			4	4	4		
Muhlenbergia sylvatica Torr.	a	4								
Muhlenbergia mexicana (L.) Trin.	c	4								
Muhlenbergia racemosa (Michx.) B. S. P.	c	4								
Agrostis alba L.	c			3						
Poa triflora Gilib.	c	3								
Poa pratensis L.	i			3						
Festuca nutans Spreng.	a	3		3						
Bromus ciliatus L.	c	4								
Bromus purgans L.	a			3						
Elymus virginicus L.	b	3				4				3
Elymus striatus Willd.	a	3		3		3				
Hystrix patula Moench.	a			3						3
Family *Cyperaceæ*										
Carex rosea Schk.	a			4						
Carex gravida laxiflora Bail.	b	4		4						
Carex pubescens Muhl.	c			4						
Carex eburnea Boott.	b									5
Carex laxiflora blanda (Dew.) Boott.	c			4						
Carex laxiflora latifolia Boott.	a	4								
Carex longirostris Torr.	b			3						
Family *Araceæ*										
Arisæma triphyllum (L.) Schott.	a			5			5			4
Family *Liliaceæ*										
Uvularia grandiflora Sm.	a			3			3			3
Allium tricoccum Ait.	a			3			3			
Smilacina racemosa (L.) Desf.	a			4						
Smilicina stellata (L.) Desf.	b			4			4			
Polygonum commutatum (R. & S.) Diet.	b	3	3	3		3		3		
Smilax herbacea L.	b	4		4						
Smilax ecirrhata (Eng.) Wats.	a	4		4			4			
Smilax hispida Muhl.	b	4		4		4				4
Family *Orchidaceæ*										

		I	II	III	IV	V	VI	VII	VIII	IX
Cypripedium parviflorum pubescens (Willd.) Kn.	a								5	
Subclass II — DICOTYLEDONEÆ										
Family *Salicaceæ*										
Salix nigra Marsh.	c									4
Salix amygdaloides Anders.	c	3	3		3	3	3	3		3
Salix longifolia Muhl.	c		4		4			4		4
Salix cordata Muhl.	c								3	4
Salix discolor Muhl.	c	4	4					4		4
Populus tremuloides Michx.	b		3	3	3	3	3	3		3
Populus deltoides Marsh.	c	4	3		3	4	3	3	3	3
Family *Juglandaceæ*										
Juglans nigra L.	a			3	4					3
Carya ovata (Mill.) K. Koch.	a		5							
Carya cordiformis (Wang.) K. Koch.	a			3	4	4	3	3		4
Family *Betulaceæ*										
Corylus americana Walt.	b		4	3	3	4	3			3
Ostrya virginiana (Mill.) K. Koch.	b	3	3	3	3	3	3	3		3
Family *Fagaceæ*										
Quercus alba L.	a	5								
Quercus macrocarpa Michx.	b	2	1	2	3	2	2	2	3	3
Quercus rubra L.	a			3	3					3
Family *Urticaceæ*										
Ulmus fulva Michx.	b	3	3	3	3	3	3	3		3
Ulmus americana L.	a	3		3	3	3	3	3		3
Ulmus racemosa Thom.	a									4
Celtis occidentalis L.	b			4	4			4		4
Celtis occidentalis crassifolia (Lam.) Gray	b		4			4	4	4		
Urtica gracilis Ait.	c	3		3				3		
Laportea canadensis (L.) Gaud.	a	3		3						
Pilea pumila (L.) Gray.	a	3	4	3			3	3		
Boehmeria cylrindrica (L.) Sw.	a			4						
Parietaria pennsylvanica Muhl.	a	4								
Family *Aristolochiaceæ*										
Asarum canadense acuminatum Ashe.	a									3
Family *Polygonaceæ*										
Polygonum pennsylvanicum L.	c					3				
Polygonum acre H. B. K.	c	3		3						
Family *Chenopodiaceæ*										
Chenopodium hybridum L.	a	3	4	3		4		4		

		I	II	III	IV	V	VI	VII	VIII	IX
Chenopodium Boscianum Moq.	a	4								
Family *Caryophyllaceæ*										
Stellaria longifolia Muhl.	c	4								
Silene stellata (L.) Ait. f.	b	3	3	3				3		3
Family *Ranunculaceæ*										
Ranunculus abortivus L.	c			3			3			
Ranunculus septentrionalis Poir.	c						4			
Thalictrum dioicum L.	a	3	4	3		4				
Thalictrum dasycarpum L.	b	3	3	3			3			
Hepatica acutiloba DC.	a									3
Anemone virginiana L.	a	3		3				3	3	
Anemone canadensis L.	c			4						
Clematis virginiana L.	b	4	4							
Aquilegia canadensis L.	b	3		3		4	3	3		3
Actæa rubra (Ait.) Willd.	a						4		4	4
Actæa alba (L.) Mill.	a						4		4	4
Family *Menispermaceæ*										
Menispermum canadense L.	a	4		4				4		4
Family *Berberidaceæ*										
Caulophyllum thalictroides (L.) Michx.	a			4						4
Family *Papaveraceæ*										
Sanguinaria canadensis L.	a			4			4		4	4
Family *Fumariaceæ*										
Dicentra cucullaria (L.) Bernh.	a			4		4	4			
Corydalis micrantha (Eng.) Gray	b			4						
Family *Cruciferæ*										
Erysimum cheiranthoides L.	b	4								
Dentaria laciniata Muhl.	a			4			4			
Arabis dentata T. & G.	b			4						
Family *Saxifragaceæ*										
Ribes gracile Michx.	b	2	3	3	3	4	3	3		3
Ribes floridum L'Her.	c	3	4		4	4	3	4		
Family *Rosaceæ*										
Amelanchier canadensis (L.) Medic.	b		4	4	4	4	4			4
Amelanchier spicata (Lam.) C. Koch.	b	5	5							
Cratægus punctata Jacq.	b	4	4	3				3		4
Cratægus Margaretta Ashe.	b		4	4						
Cratægus tomentosa (?)	b				.4					
Cratægus mollis (T. & G.) Sch.	b	4	4	3	3		3	4		3
Cratægus macracantha Lodd.	b			4	4	4		4	4	

		I	II	III	IV	V	VI	VII	VIII	IX
Fragaria virginiana Duch.	b			3			3			
Fragaria virginiana illinœnsis (Pr.) Gray.	a	3					4			
Fragaria vesca americana Post.	b			4						4
Potentilla monspeliensis L.	b	3		3						
Geum canadense Jacq.	b	3	4	3		4	3	3		3
Geum virginianum L.	a	4		4	4			4		
Geum macrophyllum Willd.	a				4				3	
Rubus occidentalis L.	b	4	4	4				4		4
Agrimonia gryposepala Wallr.	a	4		4						
Agrimonia striata Michx.	a	3		3		4	3			
Rosa blanda Ait.	b	4		4		4		4		4
Prunus serotina Ehrh.	a					5				
Prunus virginiana L.	b	4	3	3	4	3	3	3		3
Prunus americana Marsh.	b	3	3	3	3	3		3		3
Family *Leguminosæ*										
Gymnocladus dioica (L.) Koch.	a					5				
Amorpha fruticosa L.	c	4	4					4		4
Desmodium grandiflorum (Walt.) DC.	a	3				4				
Amphicarpa monoica (L.) Ell.	b	4				4	4			
Family *Oxalidaceæ*										
Oxalis filipes Small.	b	3		3						
Family *Rutaceæ*										
Zanthoxylum americanum Mill.	b	3		4	3	4	3	4	3	3
Family *Anacardiaceæ*										
Rhus glabra L.	b	3	3	3	3	3		3		3
Rhus toxicodendron L.	b	3	3	3	3	3				
Family *Celastraceæ*										
Celastrus scandens L.	b	4	4	4		4		4		4
Family *Aceraceæ*										
Acer saccharum Marsh.	a					4				
Acer saccharum nigrum (Michx. f.) Britt.	a					5				4
Acer saccharinum L.	c									4
Acer negundo L.	c	4		4	4	4		4		4
Family *Balsaminaceæ*										
Impatiens pallida Nutt.	c			3						
Impatiens biflora Walt.	c			3						3
Family *Vitaceæ*										
Psedera quinquefolia (L.) Greene.	a	3	3	3		3	3	3		3
Vitis vulpina L.	b	3	3	3	3	3	3	3		3
Family *Tiliaceæ*										
Tilia americana L.	a	4	4	3	4	4	4	4		3

		I	II	III	IV	V	VI	VII	VIII	IX
Family *Violaceæ*										
Viola cucullata Ait.	c			3			3	4		
Viola palmata L.	b	5								
Viola sororia Willd.	a	3					3			
Viola pubescens Ait.	a			3						
Viola scabriuscula Schw.	a			3			3			
Family *Onagraceæ*										
Œnothera biennis L.	b	4								
Circæa lutetiana L.	a		4	3		3	3	3		
Family *Araliaceæ*										
Aralia racemosa L.	a	4		4						4
Aralia nudicaulis L.	a									4
Family *Umbelliferæ*										
Sanicula marilandica L.	a	3	3	3		3		3		3
Osmorrhiza Claytoni (Michx.) Clarke.	a			3						3
Osmorrhiza longistylis (Torr.) DC.	a	3		3		3		3		
Osmorrhiza longistylis villicaulis Fern.	a			4						
Cryptotænia canadensis (L.) DC.	a	3		3		3		3		3
Zizia aurea Koch.	b	3	3	3						4
Tænidia integerrima (L.) Drude.	b	4		4						
Thaspium aureum Nutt.	b	4		4						
Heracleum lanatum Michx.	c	3		4		4	4			
Family *Cornaceæ*										
Cornus stolonifera Michx.	c	4				4				
Cornus paniculata L'Her.	b		3			3	3	3	3	3
Cornus alternifolia L. f.	a								4	4
Family *Ericaceæ*										
Monotropa uniflora L.	a	5								
Family *Primulaceæ*										
Steironema ciliatum (L.) Raf.	c	5		5						
Family *Oleaceæ*										
Fraxinus pennsylvanica lanceolata (Bork.) Sarg.	b	3	3	3	3	3	3	3		3
Family *Apocynaceæ*										
Apocynum androsæmifolium L.	b			3						
Family *Convolvulaceæ*										
Cuscuta obtusiflora HBK.	c			3					3	
Family *Polemoniaceæ*										
Phlox divaricata L.	a			2			2			3
Polemonium reptans L.	a			3						
Family *Hydrophyllaceæ*										

		I	II	III	IV	V	VI	VII	VIII	IX
Hydrophyllum virginianum L.	a	3		3			3			
Ellisia nyctelea L.	b			3						
Family *Boraginaceæ*										
Lappula virginiana (L.) Greene	a	4	4		3	4	4	3		3
Lappula deflexa americana (Gray) Greene	b	4								
Family *Verbenaceæ*										
Verbena urticæfolia L.	b						4	4		
Family *Labiatæ*										
Teucrium canadense L.	b			4						
Agastache scrophulariæfolia (Willd.) Ktze.	b	4		4		4			4	4
Agastache fœniculum (Pursh.) Ktze.	b	5								
Physostegia parviflora Nutt.	c			5						
Stachys palustris L.	c			3						
Monarda fistulosa L.	b	3	3	3						
Family *Solanaceæ*										
Solanum nigrum L.	c	3								3
Family *Scrophulariaceæ*										
Scrophularia marilandica	b	4		4						4
Veronica virginica L.	b							4		
Family *Orobanchaceæ*										
Orobanche uniflora L.	b	5								
Family *Phrymaceæ*										
Phryma leptostachya L.	a	3		3		3				
Family *Plantaginaceæ*										
Plantago Rugelii DC.	b			3						
Family *Rubiaceæ*										
Galium aparine L.	c			3			3			
Galium latifolium Michx.	a	4								4
Family *Caprifoliaceæ*										
Lonicera sempervirens L.	a			3						
Lonicera dioica L.	b	4								
Symphoricarpos occidentalis Hook.	b	3	3	3	3	3	3	3		3
Symphoricarpos orbiculatus Moench.	b							4		3
Triosteum perfoliatum L.	a			4						
Viburnum lentago L.	b	3		3	4	4	3	4		
Viburnum prunifolium L.	b	4								
Sambucus canadensis L.	c	3						3		3
Family *Cucurbitaceæ*										
Sicyos angulatus L.	c							4		
Echinocystis lobata (Michx.) T. & G.	c				4					

		I	II	III	IV	V	VI	VII	VIII	IX
Family *Campanulaceæ*										
Campanula americana L.	a	3		3		3		3		3
Family *Compositæ*										
Eupatorium purpureum L.	a			3						3
Epatorium urticæfolium Reich.	a	3	3	3		3				3
Solidago latifolia L.	a	4		3					3	3
Solidago canadensis L.	b		4	4						
Solidago serotina gigantea (Ait.) Gray.	c	3								3
Aster cordifolius L.	a	3		3		3				3
Aster sagittifolius Wade.	b			3						
Aster Drummondii Lindl.	a		3	3		3				
Aster paniculatus Lam.	c							4		
Erigeron philadelphicus L.	c	4		4						4
Erigeron annuus (L.) Pers.	b			3						
Antennaria neglecta Greene.	b			4						
Silphium perfoliatum L.	c			4		4				
Ambrosia trifida L.	c			3						
Ambrosia trifida integrifolia (Muhl.) T. & G.	c	4								
Rudbeckia triloba L.	b			4						
Rudbeckia laciniata L.	c	4		4		4			4	4
Helianthus decapetalus L.	b			3						
Helianthus tuberosus L.	b	3		3						
Helianthus tuberosus subcanescens Gray.	b					5				
Bidens vulgata Greene.	c	3								
Helenium autumnale L.	c			4						
Senecio balsamitæ Muhl.	c			4						
Cirsium discolor (Muhl.) Spr.	b								4	
Circium altissimum (L.) Spr.	b	3				3				
Lactuca canadensis L.	b	3								
Lactuca ludoviciana (Nutt.) Ridd.	b			4	4					
Hieracium canadense Michx.	b	4								

In addition to the forms included in the lists the following species have been collected. They are introduced plants and weeds. The fungi occur mostly on crop plants, and the weeds are most abundant in the groves which have been pastured. The first group of fungi was included in Giddings' original list.

PARASITIC FUNGI

Erysiphe polygoni DC., on *Polygonum aviculare.*
Ustilago avenæ (Pers.) Jens., on oats.
Ustilago neglecta Niess., on foxtail.
Ustilago nuda (Jens.) Kell. & Sw., on barley.

Ustilago tritici (Pers.) Jens., on wheat.
Ustilago zeæ (Beckm.) Ung., on corn.

Arthur also reported the following:

Puccinia coronata Corda, on *Avena sativa.*
Ustilago segetum (Bull.) Ditt., on *Avena sativa.*
Peronospora effusa (Grev.) Rabh., on *Chenopodium album.*

INTRODUCED WEEDS OF THE WOODS

Arctium minus Bernh.
Cirsium lanceolatum (L.) Hill.
Cannabis sativa L.
Chenopodium murale L.
Capsella bursa-pastoris (L.) Medic.
Dracocephalum parviflorum Nutt.
Euphorbia cyparissias L.
Leonurus cardiaca L.
Linaria vulgaris Hill.
Lychnis alba Mill.
Melilotus alba Desv.
Melilotus officinale (L.) Lam.
Nepeta cataria L.
Nepeta hederacea (L.) Trev.
Pastinaca sativa L.
Solanum nigrum L.
Sonchus asper (L.) Hill.
Sisymbrium officinale (L.) Scop.
Taraxacum officinale Web.
Trifolium procumbens L.

Nepeta cataria is exceedingly abundant in some of the pastured groves.

In the preceding lists the nomenclature of Gray's Manual, 7th ed., is employed in the main for vascular plants; Saccardo's Sylloge Fungorum for fungi; and Macbride's North American Slimemoulds for Myxomycetes. The discussion of synonymy, etc., will be taken up later, in the annotated list to be published.

CONCLUSIONS

1. The lake region furnishes striking and added evidence of the influence of atmospheric factors on the formation of prairies, and emphasizes the conclusion that exposure to dry winds and sun is the chief cause, even the proximity to larger lakes being insufficient to overcome these factors excepting where topography permits the accumulation of vapors.

2. The variation of the soils in which prairie plants grow from fine prairie loam to sand and gravel again demonstrates that fineness of soil is not the determining factor in prairie formation.

3. The deep woods flora of the region represents an attenuation of the easterly and southeasterly forest flora.

4. The borders of the prairie groves, and the more open groves, present a combination of ecological and floral conditions which clearly mark them as transition areas.

5. The hydrophytic flora is unusually rich and varied for this state, and offers the best opportunity within its limits for the study of deeper water forms.

FURTHER DESIDERATA

The writer had hoped to add to this paper an annotated systematic list of all the plants, together with a discussion of seasonal aspects, but the limited space renders this impossible at present. This will be published later when the crytogams will have been further elaborated, and a key to them will be included.

Other subjects, such as zonal studies in the larger lakes, the closer investigation of introduced forms, the detailed study of variation in distribution and succession among the marsh and aquatic plants, variations in the color of prairie flowers, etc., offer a promising field.

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[16] The several Fitzpatrick papers in this Bibliography contain references to Dickinson County plants. Almost without exception they are credited to the Herbarium of the State University, and in all such cases (and this applies equally to the great majority of similar references for other counties of the state), the specimens were collected, and in most cases identified, by the present writer, though these facts do not appear in the papers cited.

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Boot, David H. —

APPENDIX

THE MOLLUSCA OF THE OKOBOJI REGION

The varied physical and ecological conditions described in the botanical part of this paper offer a variety of habitats to mollusks and make this fauna of unusual interest. The abundance of lakes and swamps has naturally led to the development of a rich aquatic fauna which is marked, however, by great numbers of individuals rather than of species. These may be roughly divided into lacustrine and palustral species, the former occupying the more permanent bodies of water, such as lakes and larger ponds, and the latter the borders of the lakes, the smaller kettleholes, and the swamps and bogs. A third aquatic fauna of the fluviatile type is furnished by the Little Sioux river on the west, and the Des Moines river only a few miles east of our territory, the latter being richer in species. The comparative study of the fauna of these two streams is rendered especially interesting because the streams belong to distinct drainage systems, as has been noted.

The freshwater Pulmonates are practically restricted to the shallower waters or to the more prominent belt of submerged aquatic vegetation, which does not exceed 30 feet in depth. The gill-bearing forms, both univalve and bivalve, are found mostly in more permanent bodies of water, and often extend to greater depths.

The dry prairie furnishes very few species and individuals, and all are terrestrial Pulmonates. In the occasional clusters of *Symphoricarpos occidentalis* a few specimens of *Vallonia gracilicosta, Bifidaria holzingeri, Zonitoides minusculus*, and more rarely *Vallonia parvula, Bifidaria armifera*, etc., may be found, but on the whole the true prairie is devoid of mollusks. The more or less xerophytic forest borders show a larger number of both

species and individuals, the following appearing in addition to the species noted above:

Zonitoides arboreus	*Cochlicopa lubrica*
Vitrea hammonis	*Euconulus fulvus*
Helicodiscus parallelus	*Succinea avara*

The deeper woods furnish a larger number of species, as might be expected. They include all the border forms mentioned, and a number of additional species which are listed in the first column of the table.

The distribution of the species occurring in borders and woods is usually quite local. On dewy mornings, or during and after rains, they may be found creeping upon various herbaceous plants, or in some cases upon the bark of living tree-trunks. One of the most abundant species occurring on tree trunks is *Bifidaria corticaria*, which is most frequent upon the red elm, but also occurs on green ash, bur oak, and other trees. Dr. T. C. Stephens, Mr. Glenn I. Tenney and the writer collected numerous specimens in such locations on rainy days. With them were found a few specimens of *Vallonia gracilicosta*, *V. parvula*, *Bifidaria holzingeri*, *Zonitoides arboreus* and *Pyramidula striatella*.

In dry weather these terrestrial forms are found in great abundance under fallen leaves of trees, and any fairly well protected bank or slope on which the leaf mulch has not been disturbed is sure to yield a number of species. Most of these species may also be found under logs and sticks, and in and about rotten stumps.

Quite frequently dead specimens of both terrestrial and aquatic forms are thrown upon the beaches with finer drifted materials, and often an opportunity is thus presented to gain a ready knowledge of the local molluscan fauna. Extensive lacustrine deposits in Upper Gar lake and in the swamp south of Miller's Bay also offered fine opportunities for learning something of the earlier fauna of the region at the time that the canals were being excavated.

Some conception of the several faunas mentioned may be obtained from the accompanying table, in which type habitats within our area, rather than specific localities, are indicated.

The following symbols are employed in the table:

1.— As in the botanical tables, Roman numerals are employed

to mark types of localities. These appear at the head of each column and are explained as follows:

I. — Terrestrial species from the forest and forest border areas.

II. — Aquatic, mostly pulmonate forms, from shallow waters and swamp borders. Here are also included several species, marked by asterisks, which are only semi-aquatic, living on wet borders, etc. They are sometimes truly terrestrial.

III. — Aquatic species from the deeper waters of the lakes and larger ponds.

IV. — Fluviatile forms from the Little Sioux river.

V. — Fluviatile forms from the Des Moines river at Estherville.

VI. — Species from the lacustrine deposits south of Miller's Bay and at the northern extremity of Upper Gar lake.

2. — The numbers in the columns indicate the abundance and extent of distribution as follows: 1 marks species which are very common and widely distributed; 2 indicates rather common species, less abundant but generally distributed; 3 denotes that the species is quite widely distributed, but is nowhere common; 4 marks rare species; and 5 designates species now extinct in this region. Of the latter one species, *Lymnæa megasoma*, has existed in the region within a half century, as specimens were collected by the White Geological Survey.

TABLE OF MOLLUSCA

	I	II	III	IV	V	VI
Polygyra profunda (Say) Pils.	4					
Polygyra fraterna (Say) Pils.	3					
Polygyra monodon (Rack.) Pils.	4					
Bifidaria contracta (Say) Sterk.	2					
Bifidaria armifera (Say) Sterk.	2					
Bifidaria corticaria (Say) Sterk.	2					
Bifidaria pentodon (Say) Sterk.	2					
Bifidaria holzingeri (Sterk.)	2					
Bifidaria curvidens (Gld.) Sterk.	4					
Pupoides marginatus (Say) Pils. & Van.	4					
Vertigo ovata Say	3					
Vertigo milium (Gld.) Binn.	3					
Vertigo tridentata Wolf.	3					
Cochlicopa lubrica (Muell.) Fer.	2					

	I	II	III	IV	V	VI
Circinaria concava (Say) Pils.	4					
Zonitoides minusculus (Binn.) Pils.	3					
Zonitoides arboreus (Say) Pils.	2					
* Zonitoides nitidus (Muell.) Pils.	4	3				4
Vitrea hammonis (Strom.) Pils.	2					3
Euconulus fulvus (Drap.)	2					
Pyramidula alternata (Say) Pils.	1					
Pyramidula striatella (Anth.) Pils.	2					
Helicodiscus parallelus (Say)	2					
Punctum pygmæum (Drap.) Binn.	2					
* Succinea retusa Lea	3	1				2
Succinea avara Say	2					3
* Succinea witteri Shim.	4	4				
Agriolimax campestris (Say)	3					
Phylomycus carolinensis (Bosc.) Fer.	4					
* Carychium exiguum (Say) Gld.	3	3				
Lymnæa megasoma Say						5
Lymnæa stagnalis jugularis (Say) Walk.		3				3
Lymnæa emarginata angulata (Sower.)			3			
Lymnæa palustris (Muell.) Sower.		3				2
Lymnæa elodes Say		3				2
Lymnæa reflexa Say		4				3
Lymnæa exilis Say		3				3
Lymnæa caperata Say		2				2
Lymnæa obrussa Say		3				
Lymnæa modicella (Say) Jay		2				
Lymnæa parva Lea		3				
Physa integra Hald.					2	
Physa sayi Tapp.		2				2
Physa gyrina Say		1				2
Aplexa hypnorum (L.) Chem.		2				2
Planorbis campanulatus Say			1			2
Planorbis bicarinatus Say		2	2			2
Planorbis truncatus Miles			3			3
Planorbis trivolvis Say		1				2
Planorbis exacutus Say		2				3
Planorbis albus Muell.		2	3			3
Planorbis deflectus Say		3				2
Planorbis parvus Say		1				2
Planorbis dilatatus Gld.		3				
Segmentina armigera (Say) H. & S. Ad.		3				3
Ancylus parallelus Hald.						5
Ancylus rivularis Say				3	2	
Ancylus diaphanus Hald.		4				
Valvata tricarinata Say		3	1			1
Valvata bicarinata Lea			4			

	I	II	III	IV	V	VI
Valvata lewisii Cur.						5
Bythinella obtusa (Lea) Binn.			2		3	
Somatogyrus depressus (Try.) Gill					2	
Amnicola limosa (Say) Hald.			2			
Amnicola cincinnatiensis Anth.			1			2
Amnicola sayana Anth.			3			
Pomatiopsis cincinnatiensis (Anth.)			2			3
Campeloma obesum Lewis					3	
Campeloma subsolidum (Anth.) Call					3	
Campeloma decisum (Say) Call		3	2	3		
Pisidium compressum Pr.		3				
Pisidium abditum Hald.		3	1			2
Pisidium peraltum Sterk. (?)				4		
Musculium transversum (Say) Sterk.				3		
Musculium partumeium (Say) Sterk.		2	2			
Sphærium simile (Say)		3	3			3
Sphærium sulcatum (Lam.) Pr.		2				
Sphærium striatinum (Lam.) Pr.					2	
Lampsilis alatus (Say) Bak.					2	
Lampsilis ventricosus (Barnes) Bak.				2	2	
Lampsilis parvus (Barnes) Bak.					3	
Lampsilis subrostratus (Say) Simp.				3	3	
Lampsilis rectus (Lam.) Sm.					2	
Lampsilis anodontoides (Lea) Bak.					3	
Lampsilis luteolus (Lam.) Bak.			1	1	1	
Lampsilis ligamentinus (Lam.) Sm.					1	
Lampsilis ellipsiformis (Con.) Simp.					3	
Unio gibbosus Barnes					2	
Quadrula plicata (Say) Bak.					3	
Quadrula undulata (Barnes) Bak.				1	1	
Quadrula metanevra (Raf.) Simp.					3	
Quadrula lachrymosa (Lea) Bak.					3	
Quadrula pustulosa (Lea) Bak.					2	
Quadrula coccinea (Con.) Bak.					3	
Quadrula trigona (Lea) Bak.					3	
Quadrula rubiginosa (Lea) Bak.				3	3	
Obovaria ellipsis (Lea) Simp.					4	
Tritogonia tuberculata (Barnes) Simp.					3	
Pleurobema æsopus (Green) Simp.					3	
Obliquaria reflexa (Raf.) Bak.					4	
Symphynota complanata (Barnes) Simp.				2	2	
Symphynota costata (Raf.) Simp.					2	
Symphynota compressa Lea					3	
Alasmidonta truncata B. H. Wr.					4	
Strophitus edentulus (Say) Simp.					2	
Anodontoides ferussacianus (Lea) Bak.			3	3	3	

	I	II	III	IV	V	VI
Anodontoides ferussacianus subcylindraceus (Lea) Simp.			3			
Anodonta imbecillis Say				3	3	
Anodonta grandis Say		2	2	2	2	
Anodonta footiana Lea			1			

The foregoing list is based chiefly on collections made by the writer, but additional material was obtained from Dr. Stephens and Mr. Tenney. A partial list of the mollusks of this region was included in the paper on "Alluvial Fossils and Modern Drifted Shells," published by the writer as a supplement to the address of the vice-president of Section E, Am. Ass'n for the Advancement of Science, 1913. A smaller list was also published in The Iowa Geological Survey, vol. XX, p. 329; 1910.

Undoubtedly other species will be found, and to assist the student in determining such discoveries a key to most of the mollusks known from the state is appended. A more complete list and key will be published in the near future, and this will include all the bivalves known from the state, the present key giving only those which are known from this territory. A more critical review of the nomenclature will then be included. For the present the writer makes use of certain well-known names which are probably no longer tenable.

The key consists of two parts, the first being a key to the genera, and the second to species. The numbers following the generic names in the first key correspond to the numbers preceding the same names in the second part.

KEY TO THE GENERA OF MOLLUSCA OF IOWA

I—Animal without external shell; terrestrial.

Slug mottled, light colored, more than 75 mm. long; no internal shell.
Genus PHILOMYCUS 1

Slug not more than 25 mm. long, darker and more uniform in color.

Mantle covering whole body; no internal shell.
Genus PALLIFERA 2

Mantle covering only anterior part of body; with rudimentary shell. Genus AGRIOLIMAX 3

II—With univalve shell.

A—Operculate, mostly aquatic.

a—Shell more than 10 mm. long.

1—Whorls distinctly flattened, spire exserted, conical. Aperture with notch or short canal.
Genus PLEUROCERA 4

Aperture rounded in front, without notch or canal.
Genus GONIOBASIS 5

2—Whorls more rounded, suture impressed.

Shell rather thin, whorls very rounded, color usually dark, often with color bands. Genus VIVIPARA 6

Shell heavy, spire produced, whorls all slightly flattened, color usually light greenish.

Length more than 15 mm., at least twice the diameter.
Genus CAMPELOMA 7

Length less than 15 mm., less than twice the diameter.
Genus LIOPLAX 8

b—Shell less than 10 mm. long.

1—Spire distinctly longer than the aperture.

Whorls flattened or carinate, apex acute.
Genus PYRGULOPSIS 9

Whorls rounded, apex obtuse.

Brownish, 5 mm. long; terrestrial.
Genus POMATIOPSIS 10

Greenish, 2/3 mm. long; aquatic.

Conical. Genus POMATIOPSIS 10

Subcylindrical, obtuse. Genus BYTHINELLA 11

2—Spire not exceeding aperture.

Whorls rounded.

Shell very oblique. Genus SOMATOGYRUS 12

Shell more regularly conical. Genus AMNICOLA 13

Whorls flat or sharply angular.

Suture prominent, whorls shouldered, carinate; umbilicus wide and deep. Genus VALVATA 14

Suture scarcely impressed, whorls flattened; umbilicus closed; terrestrial. Genus HELICINA 15

B—Not operculate.

a—Aquatic.

1—Shell conical, limpet-like (not spiral).

Apical cap and internal shelf present.
Genus GUNDLACHIA 16

Apical cap and internal shell absent. Genus ANCYLUS 17

2—Shell conical, spiral.

Dextral. Genus LYMNÆA 18

Sinistral.

Narrow, with exserted spire; polished.
Genus APLEXA 19

Broader, spire shorter; usually less polished.
Genus PHYSA 20

3—Shell flattened, spire not exserted.

Aperture with teeth or folds. Genus SEGMENTINA 21

Aperture unarmed. Genus PLANORBIS 22

b—Terrestrial.

1—Cylindrical or elongated fusiform-conical, with elongated body-whorl and aperture; polished; 6x2.5 mm.
Genus COCHLICOPA 23

2—Cylindrical or elongated conical, with short body-whorl and rounded aperture; less than 5x1.5 mm.

*—Peristome sharp, aperture circular, whorls numerous, narrow, shell distinctly cylindrical, aperture unarmed. Genus SPHYRADIUM 24

**–Peristome more or less reflexed or expanded, aperture more or less armed with teeth or folds.

i—Aperture with one columellar fold; shell minute, white, with oblique whorls. Genus CARYCHIUM 25

ii—Aperture usually variously armed with teeth; no columellar fold.

o—Teeth none, or one (rarely two) on parietal wall only, shell more than 3 mm. long.

Conical, aperture without teeth, peristome thickened and reflexed. Genus PUPOIDES 26

Subcylindrical, peristome scarcely reflexed; aperture usually armed. Genus PUPILLA 27

oo–Teeth usually on both the parietal wall and peristome; shell less than 3 mm. long.

Whitish or horn colored, with a double or furcate parietal tooth; if brownish only parietal tooth present. Genus BIFIDARIA 28

Brownish or brown, teeth various, on both walls of aperture. Genus VERTIGO 29

3—Depressed conical or flattened.

*—Peristome sharp, or slightly thickened.

i—Shell longitudinally ribbed or striate; surface dull.

o—Minute, less than 2 mm. in diameter.
Genus PUNCTUM 30

oo–Larger, more than 5 mm. in diameter.

With continuous spiral colored band; loess fossil. Genus OREOHELIX 31

Colored bands absent, or interrupted.
Genus PYRAMIDULA 32

ii—Shell horn colored, or if brown, polished.

o—Diameter more than 20 mm.
Genus CIRCINARIA 33

oo–Diameter less than 10 mm.

Shell compact-conical, whorls narrow.
Genus EUCONULUS 34

Shell more or less depressed.

Spire very flat, whorls narrow, umbilicus very wide, aperture with small teeth or folds. Genus HELICODISCUS 35

Spire slightly elevated, convex.

Whorls rapidly enlarging as seen from above, umbilicus narrow.
Genus VITREA 36

Whorls enlarging more gradually, suture more impressed, whorls more rounded above. Genus ZONITOIDES 37

**–Peristome more or less reflexed.

i —Shell not more than 3 mm. in diameter.

Conical, compact, whorls narrow, body whorl with revolving lamellæ within. Genus STROBILOPS 38

Depressed, with rapidly enlarging whorls; aperture without teeth or folds. Genus VALLONIA 39

ii—Shell more than 5 mm. in diameter.
Genus POLYGYRA 40

4—Shell very oblique, body whorl enlarged and elongated.
Genus SUCCINEA 41

III–With bivalve shell.

A—Small, less than 25 mm. long.

a—Very oblique, mostly very small and inflated.
Genus PISIDIUM 42

b—Less oblique, larger.

Valves very thin, fragile. Genus MUSCULIUM 43

Valves thicker; opaque and usually brown.
Genus SPHÆRIUM 44

B—Larger, more than 25 mm. long.

a—Pseudocardinal and lateral teeth both present. (The old genus *Unio*.)

1—Without tubercles or plications.

*—Elongated, lower margin usually nearly parallel with hinge line.

Shining, usually rayed; beaks sculptured with fine ridges; sometimes winged above the hinge.
Genus LAMPSILIS 45

Dull, not rayed; beaks with coarse ridges; not winged. Genus UNIO 46

(Toothed forms of *Margaritana monodonta* might also be sought here.)

**–More nearly isodiametric.

i —Posterior ridge well developed.

o—Epidermis dull brown.
Genus QUADRULA (in part) 47

oo–Epidermis greenish or yellow; usually with rays.

Posterior truncate area with longitudinal wrinkles. Genus TRUNCILLA 48

Posterior truncate area without distinct longitudinal wrinkles. Genus PLAGIOLA 49

ii—Posterior ridge absent or indistinct.

Very oblique, with beaks well at anterior end. Genus OBOVARIA 50

Less oblique. Genus QUADRULA (in part) 47

2—With tubercles or plications.

*—Elongated.

Tubercles numerous, well defined. Genus TRITOGONIA 51

Indistinct tubercles or short folds extending across shell in oblique row from beak. Genus PLEUROBEMA 52

Shell somewhat wrinkled posteriorly, often winged. Genus SYMPHYNOTA (in part) 56

**–More nearly isodiametric.

Tubercles, or knobs very large, in one row. Genus OBLIQUARIA 53

Tubercles less prominent, few or many, not restricted to one row.

Beak sculpture very faint. Genus CYPROGENIA 54

Beak sculpture coarse. Genus QUADRULA (in part) 47

b—Pseudocardinal teeth present, laterals absent or indistinct. (The old genus *Margaritana.*)

1—Elongated, ends rounded or merely angular.

*—Less than 5 cm. long, elliptical, ends rounded. Genus HEMILASTENA 55

**–Distinctly larger.

Posterior end angular, wrinkled. Genus SYMPHYNOTA (in part) 56

Ends rounded, epidermis dark. Genus MARGARITANA 57

(Some forms of *Lampsilis leptodon*, lighter colored and usually rayed, might be sought here.)

2—Isodiametric, or abruptly truncated.

Surface with plications and wrinkles. Genus ARCIDENS 58

Plications none, or obscure and only on truncate end. Genus ALASMIDONTA 59

c—Hinge without well developed teeth. (The old genus *Anodonta.*)

1—Rather heavy for the group, dark, opaque. Genus STROPHITUS 60

2—Thinner, more or less greenish.

Elliptical, base and hinge line parallel.

Genus ANODONTOIDES 61

Ovate, etc., narrowing more or less posteriorly.

Genus ANODONTA 62

(Toothless forms of *Margaritana monodonta* and *Lampsilis leptodon* might be sought in this group. The former is heavy, nearly 3 times as long as wide, dark and opaque. The latter is flat, has more or less distinct rays, and the valves are somewhat distorted, and do not fit closely.)

KEY TO SPECIES

In the following key the name only is given when the genus is represented by but one species in Iowa. The numbers preceding the names correspond to the numbers opposite the generic names in the preceding key.

1.—*Philomycus carolinensis* (Bosc.) Fer.

2.—*Pallifera dorsalis* (Binn.) Morse.

3.—*Agriolimax campestris* (Say).

4.—*Pleurocera subulare* (Lea) Try.

5.—*Goniobasis livescens* (Mke.) Try. The form with angular bodywhorl and more prominent suture, due to carina on whorls, also occurs. It is known as *G. cubicoides* (Anth.) Try.

6.—*Vivipara*

With 4 distinct reddish-brown spiral bands; umbilicus partly opened. *V. contectoides* Binn.

Colored bands none, or obscure; umbilicus closed.

Diameter about equal height; whorls all rounded. *V. intertexta* (Say) Binn.

Diameter less than height; bodywhorl often somewhat flattened above. *V. subpurpurea* (Say.) Binn.

7.—*Campeloma*

Ventricose, spire rather short.

Reddish within. *C. rufum* (Hald.) Call.

Dark olive green, not reddish. *C. obesum* Lewis

Less ventricose; spire rather elongated.

Aperture 1/3 the length of the shell. *C. subsolidum* (Anth.) Call.

Aperture more than 1/3 the length of the shell. *C. decisum* (Say) Call.

8.—*Lioplax subcarinata* (Say) Trosch.

9.—*Pyrgulopsis scalariformis* (Wolf) Call & Pils. (Alluvial fossil.)

10.—*Pomatiopsis*

Shell brownish, 5 mm. long; terrestrial. *P. lapidaria* (Say) Try.

Shell greenish, 2-3 mm. long; aquatic. *P. cincinnatiensis* (Anth.)

11.—*Bythinella obtusa* (Lea) Binn.

12.—*Somatogyrus*

Length 5 to 7 mm. *S. integer* (Say) Binn.

Length 4 mm. *S. depressus* (Try.) Gill.

13.—*Amnicola*

Length less than 3 mm.; whorls 4. *A. granum* (Say) Hald.

Length about 4 mm.; width almost equals length; whorls about 4, very convex.

Aperture usually subangular at base. *A. parva* Lea.

Aperture rounded at base. *A. limosa* (Say) Hald.

(A somewhat larger form, with less distinct umbilicus and whorls slightly transversely wrinkled, probably a variety of this species, has been reported from Iowa as *A. porata* (Say) Hald.)

Length at least 5 mm.; whorls 4 to 6.

Yellowish brown, 5.5 mm. long; whorls 6. *A. sayana* Anth.

Green; 5 mm. long; whorls 4 or 5. *A cincinnatiensis* Anth.

14.—*Valvata*

Spire elevated, whorls shouldered; usually tricarinate. *V. tricarinata* Say.

Spire flat; usually bicarinate. *V. bicarinata* Lea.

(The tricarinate form is known as *V. bicarinata var. normalis* Walk.)

15.—*Helicina occulta* Say.

16.—*Gundlachia meekiana* Stimp.

17.—*Ancylus*

Apex nearly central; not oblique.

Apex rather acute; sides of narrow shell straight and nearly parallel. *A. parallelus* Hald.

Apex obtuse; shell broadly elliptical, flattened. *A. diaphanus* Hald.

Apex oblique.

Length about 6 mm.; on rocks, etc., in streams. *A. rivularis* Say.

Length less than 4 mm.; apex radially striate.

Shell laterally compressed; apex very oblique. *A. shimekii* Pils.

Shell not compressed; apex less oblique. *A. pumilus* Sterki.

18.—*Lymnæa*

a—Distinctly more than 20 mm. in length when mature.

1—Bodywhorl inflated, much wider than spire; usually more than 25 mm. in length.

*—Apex obtuse or acute; shell more gradually enlarging, heavy, opaque, brown within the aperture; body whorl not shouldered. *L. megasoma* Say.

**—Apex acuminate; shell more transparent, without brown, opaque epidermis.

Body whorl not shouldered, white within the aperture.

L. stagnalis var. jugularis (Say) Walk.

Body whorl more or less shouldered; peristome with brown band within. *L. emarginata var. angulata* (Sowerb.)

2—Bodywhorl narrower, spire more exserted.

*—Length usually less than 2.5 times the width; length (height) of whorls distinctly less than width. *L. palustris* (Muell.) Sowb.

**–Length usually more than 2.5 times the width; length of whorls equal to or greater than width.

Whorls quite distinctly rounded, suture deep.

Shell tapering upward gradually and regularly; surface usually malleated. *L. elodes* Say.

Shell with two basal whorls relatively much longer; surface rarely malleated. *L. reflexa* Say.

Whorls somewhat flattened, suture not deep.

Slightly umbilicated; aperture with a distinct twist. *L. kirtlandiana* Lea.

Umbilicus closed; aperture long and narrow, without twist; whorls much flattened, short. *L. exilis* Lea.

b—Somewhat less than 20 mm. in length; bodywhorl much enlarged.

1—Thin, with short spire and larger bodywhorl (like *Succinea*).

Spire conic, bodywhorl convex, columella not distinctly excavated. *L. columella* Say.

Spire compressed — acuminate; body whorl flattened; columella excavated. *L. columella var. chalybea* (Gld.) Mighl.

2—Rather heavy; body whorl shouldered; aperture with brown band within. *L. emarginata var. angulata* (Sowb.)

c—Less than 17 mm. long; body whorl gradually enlarged; shell elongated conical.

1—Usually brown or brownish; with fine revolving striae; 12 to 15 mm. long. *L. caperata* Say.

2—Usually more transparent, and light in color; no revolving striae.

*—Length more than 10 mm.

Whorls 5.5; very pale horn colored; spire longer than aperture; about 12 mm. long. *L. pallida* Adams.

Whorls 5; yellowish; aperture usually about equal to spire; about 15 to 17 mm. long. *L. obrussa* Say.

**–Length less than 10 mm.

Whorls 6; length 8 to 9 mm.; umbilicus distinct; shell reddish or yellowish white. *L. modicella* (Say) Jay.

Whorls about 5; length 3 to 7 mm.; umbilicus small or closed.

Shell usually more than 4 mm. long; whorls not shouldered. *L. parva* Lea.

Shell usually less than 4 mm. long; whorls somewhat shouldered. *L. dalli* Baker.

19.—*Aplexa hypnorum* (L.) Chem.

20.—*Physa*

Body whorl shouldered, spire rather abrupt. *P. integra* Hald.

Body whorl rounded, spire more regularly conical.

Shell thin, inflated; whorls of spire rounded; aperture ⅘ the length of the shell. *P. sayi* Tapp.

Shell rather heavy; aperture less than ⅔ the length of the shell. *P. gyrina* Say.

(Other forms, probably varieties of this species, occur in the state.)

21.—*Segmentina*

Aperture white, strongly constricted; teeth 6. *S. crassilabris* Walk.

Aperture blackish, not constricted; teeth 5. *S. armigera* (Say) H. & A. Ad.

22.—*Planorbis*

Greater diameter more than 12 mm.

Body whorl constricted behind the campanulate aperture; body whorl narrow. *P. campanulatus* Say.

Body whorl not constricted, aperture not campanulate; body whorl gradually enlarging.

Sharply spirally carinate, often with second less prominent carina; diameter 12 to 13 mm. *P. bicarinatus* Say.

Not sharply carinate; diameter about 18 mm.

Whorls spirally sculptured on the lower side, and within the umbilicus. *P. truncatus* Miles.

Whorls not spirally sculptured below. *P. trivolvis* Say.

Greater diameter less than 10 mm.

Shell much flattened, with very sharp spiral carina. *P. exacutus* Say.

Shell not sharply carinate.

With revolving lines of hairs; pale. *P. albus* Muell.

Without hairs; shell horn colored.

Body whorl deflected downward, rounded; diameter 19 mm. *P. deflectus* Say.

Body whorl scarcely deflected; diameter less than 10 mm.

Body whorl gradually enlarging, aperture not expanded.

Umbilicus deep, narrow; grayish white. *P. umbilicatellus* Ckll.

Umbilicus wide; shell horn colored. *P. parvus* Say.

Body whorl abruptly enlarged, aperture expanded. *P. dilatatus* Gld.

23.—*Cochlicopa lubrica* (Muell.) Fer.

24.—*Sphyradium edentulum* (Drap.) Pils.

(The elongated form with distorted body whorl which occurs in the loess is known as *S. edentulum var. alticola* (Ing.) Pils.)

25.—*Carychium*

Aperture more than ⅓ the length of the shell, body whorl relatively large. *C. exile* H. C. Lea.

Aperture less than 1/3 the length of the shell, body whorl smaller. *C. exiguum* (Say) Gld.

26.—*Pupoides marginatus* (Say) Pils. & Van.

27.—*Pupilla*

About 4 mm. long; aperture with 1 or 0 teeth on parietal wall. *P. muscorum* (L.)

About 3 mm. long; parietal and columellar teeth each 1, and 1 tooth at base far within. Loess. *P. blandi* Morse.

About 2.5 mm. long; apex more conical; aperture with 4 teeth. Loess. *P. decora* (Gld.)

28.—*Bifidaria*

Length 3 or more mm.; short fusiform; aperture constricted, peristome expanded, teeth 4, prominent, almost closing aperture.

Length=3 mm. *B. contracta* (Say) Sterk.

Length=4 mm. *B. armifera* (Say) Sterk.

Length less than 3 mm.; aperture not constricted.

Length 2 to 2.5 mm.; shell more or less cylindrical.

Brown; cylindrical, narrow. *B. procera* (Gld.) Sterk.

Whitish or horn colored.

Parietal tooth 1, or 0; no other teeth. *B. corticaria* (Say) Sterk.

Teeth in aperture several. *B. pentodon* (Say) Sterk.

Length less than 2 mm.

Cylindrical. *B. holzingeri* (Sterk.)

Ovate, somewhat broader. *B. curvidens* (Gld.) Sterk.

29.—*Vertigo*

Length 2 or more mm.

Length=2—2.5 mm.; diam.=1 mm.; teeth 3. *V. tridentata* Wolf.

Length=2 mm.; diam.=1 mm.; teeth 5. *V. gouldi* (Binn.) Stimp.

Length=3 mm., diameter=1.5 mm. *V. ovata* Say.

Length less than 2 mm.

Length about 1.6 mm. *V. bollesiana* (Morse)

Length less than 1 mm. *V. milium* (Gld.) Binn.

30.—*Punctum pygmaeum* (Drap.) Binn.

31.—*Oreohelix iowensis* (Pils.) Loess.

32.—*Pyramidula.*

More than 10 mm. in diameter; spotted. *P. alternata* (Say) Pils.

Less than 10 mm. in diameter; color uniform.

Reddish brown; umbilicus very wide; diameter=8 mm. *P. perspectiva* (Say) Pils.

Dull brown or horn colored; umbilicus narrow; diameter 6 mm.

Both upper and lower surfaces of body whorl distinctly ribbed or strongly striate. *P. striatella* (Anth.)

Lower surface of body whorl smooth.

(In Iowa a loess fossil only.) *P. shimekii* (Pils.) Shim.

33.—*Circinaria concava* (Say) Pils.

34.—*Euconulus fulvus* (Drap.) Reinh.

35.—*Helicodiscus parallelus* (Say)

36.—*Vitrea*

Umbilicus closed; shell with remote regular longitudinal impressed lines. *V. indentata* (Say) Pils.

Umbilicus open; no impressed lines. *V. hammonis* (Ström.) Pils.

37.—*Zonitoides*

Diameter less than 3 mm. *Z. minusculus* (Binn.) Pils.

Diameter more than 3 mm.

Whorls slightly flattened; dimensions 5 x 4.5 x 2.75 mm. *Z. arboreus* (Say) Pils.

Whorls more rounded; shell more robust; dimensions 7.5 x 6 x 3.6 mm. *Z. nitidus* (Muell.) Pils.

38.—*Strobilops*

Shell whitish. *S. virgo* (Pils.)

Shell brown, larger. *S. labyrinthica* (Say) Pils.

39.—*Vallonia*

About 3 mm. in diameter.

Whorls with numerous (but somewhat distant) fine transverse ribs. *V. gracilicosta* Reinh.

Whorls without ribs. *V. pulchella* Muell.

About 2 mm. in diameter.

Nucleus with fine revolving striae; lip thickened and reflexed. *V. parvula* Sterk.

Nucleus without revolving striae; lip thin and merely expanded. *V. perspectiva* Sterk.

40.—*Polygyra.*

Less than 12 mm. in diameter; whorls and aperture narrow.

Epidermis covered with hairs; umbilicus closed; aperture very narrow, with notch in thickened peristome. *P. hirsuta* (Say) Pils.

Epidermis without hairs; umbilicus partly opened; no notch in peristome.

Diameter about 12 mm. *P. fraterna* (Say) Pils.

Diameter less than 10 mm. *P. monodon* (Rack.) Pils.

More than 15 mm. in diameter; aperture wider.

Umbilicus wide. *P. profunda* (Say) Pils.

Umbilicus partly open.

Diameter about 18 mm.; no teeth in aperture. *P. clausa* (Say) Pils.

Diameter about 22 mm.; parietal tooth usually present. *P. thyroides* (Say) Pils.

Umbilicus closed.

Shell depressed; parietal tooth long, lamellar. *P. appressa* (Say) Pils.

Shell more elevated; parietal tooth short or wanting.

Spirally marked with reddish lines and bands, sometimes

uniformly reddish or horn colored; diameter less than 25 mm. *P. multilineata* (Say) Pils.

Without color bands; parietal tooth often present; diameter more than 25 mm. (Our Iowa form=*var. alleni*). *P. albolabris* (Say) Pils.

41.—*Succinea*

Spire very short; body whorl large, shell ovate; in swamps. *S. retusa* Lea.

Spire more elevated; whorls more rounded.

Less than 10 mm. long; spire elevated. *S. avara* Say.

More than 10 mm. long.

Whorls somewhat flattened, spirally grooved by irregular lines. *S. witteri* Shim.

Whorls rounded.

Very oblique; more than 15 mm. long. *S. ovalis* Say.

More regularly conical; less than 15 mm. long. *S. grosvenorii* Lea.

42.—*Pisidium*

Length of shell about 7 mm. *P. virginicum* (Gmel.) Bourg.

Length of shell less than 5 mm.

More than 3 mm. long.

Beaks narrow, with wing-like appendages; shell compressed. *P. compressum* Prime.

Beaks rounded, not appendaged; shell more inflated.

Beaks without ridges; shell dull. *P. peraltum* Sterk.

Beaks ridged; shell polished. *P. abditum* Hald.

Less than 2 mm. long. *P. punctatum* Sterk.

43.—*Musculium*

Less than 5 mm. long. *M. tenue* (Prime) Sterk.

More than 5 mm. long.

Transversely elongated; beaks not central. *M. transversum* (Say) Sterk.

Rhombic or suborbicular; beaks nearly central.

Length about 12 mm.

Inflated; hinge margin not short. About 12.5 x 10.75 x 7.75 mm. *M. partumeium* (Say) Sterk.

Less inflated; hinge short. About 12.5 x 10.75 x 4.5 mm. *M. jayanum* (Pr.) Sterk.

Length about 9 mm.

Inflated; about 9.25 x 7.75 x 6.25 mm. *M. securis* (Pr.) Sterk.

Not inflated; about 9.25 x 7.75 x 3.75 mm. *M. truncatum* (Lin.) Sterk.

44.—*Sphaerium*

Shell rhombic ovate, highly polished, finely concentrically striate; about 12.5 x 9.25 x 7.75 mm. *S. rhomboideum* (Say) Pr.

Shell more coarsely marked, not regularly rhombic ovate.

Transversely elongated.

Umbones quite full. About 15 to 20 x 10.75 x 7.75 mm. *S. sulcatum* (Lam.) Pr.

Shell inflated, about 17 x 12 x 9 mm.; polished. *S. simile* Say.

Shell duller, less inflated, about 15 to 20 x 10.75 x 7.75 mm. *S. sulcatum* (Lam.) Pr.

Umbones but slightly inflated; about 14 x 10.75 x 7.75 mm. *S. solidulum* Pr.

Shorter, nearly equilateral; umbones full; dimensions about 10.75 x 7.75 x 6.25 mm. *S. striatinum* (Lam.) Pr.

45.—*Lampsilis* (In this and the following genera only the species found in the region under discussion are included.)

Shell distinctly winged above hinge; flattened, rather heavy, large; nacre purple. *L. alatus* (Say) Bak.

Shell not winged, more or less inflated.

Very ventricose, rather thin; umbones prominent, but angular or ridged. *L. ventricosus* (Barnes) Bak.

More elongated, less inflated in umbonal region, sometimes nearly cylindrical.

Less than 4 cm. long, dark. *L. parvus* (Barnes) Bak.

More than 5 cm. long.

Length more than twice the height.

Epidermis almost or quite black.

Length 8-10 cm.; shell rather thin; nacre white or bluish. *L. subrostratus* (Say) Simp.

Larger; shell heavy; nacre purple or nearly white. *L. rectus* (Lam.) Sm.

Epidermis yellow. *L. anodontoides* (Lea) Bak.

Length less than twice the height.

Umbones quite prominent.

Epidermis yellow, shiny, usually rayed; female shell expanded posteriorly. *L. luteolus* (Lam.) Bak.

Epidermis darker, not as highly polished, with or without rays; umbones less prominent. *L. ligamentinus* (Lam.) Smith

Umbones depressed, shell compressed and tapering posteriorly. *L. ellipsiformis* (Con.) Simp.

46.—*Unio gibbosus* Barnes.

47.—*Quadrula*

Shell tubercled or plicate.

Plicate, without tubercles.

Umbones prominent; shell about 10.9 x 8.1 x 5.9 cm. *Q. plicata* (Say) Bak.

Umbones depressed; shell about 10.12 x 8 x 3.9 cm.
Q. undulata (Barnes) Bak.

Shell tubercled.

With a strong posterior fold or ridge.
Q. metanevra (Raf.) Simp.

Without strong fold, at most with low ridges.

Posterior ridges two; tubercles mostly in two rows.
Q. lachrymosa (Lea) Bak.

Posterior ridge one or none; tubercles usually scattered, many. *Q. pustulosa* (Lea) Bak.

Shell smooth, without folds or tubercles, sometimes with posterior ridge.

Posterior ridge absent or indistinct. *Q. coccinea* (Con.) Bak.

Posterior ridge distinct.

Umbones large; dimensions about 7.8 x 5.8 x 4.1 cm.
Q. trigona (Lea) Bak.

Umbones less inflated, shell flatter; about 5.9 x 5.8 x 3.6 cm. *Q. rubiginosa* (Lea) Bak.

48.—*Truncilla*—one species in Iowa.
49.—*Plagiola*—one species in Iowa.
50.—*Obovaria ellipsis* (Lea) Simp.
51.—*Tritogonia tuberculata* (Barnes) Simp.
52.—*Pleurobema aesopus* (Green) Simp.
53.—*Obliquaria reflexa* (Raf.) Bak.
54.—*Cyprogenia*—one species in Iowa.
55.—*Hemilastena*—one species in Iowa.
56.—*Symphynota*

Shell suborbicular, very flat, winged; teeth obsolete.
S. complanata (Barnes) Simp.

Shell elongated, more inflated, scarcely winged.

Lateral teeth absent. *S. costata* (Raf.) Simp.

Lateral teeth present. *S. compressa* Lea.

57.—*Margaritana*—one species in Iowa.
58.—*Arcidens*—one species in Iowa.
59.—*Alasmidonta truncata* B. H. Wr.
60.—*Strophitus edentulus* (Say) Con.
61.—*Anodontoides*

Shell thin, not cylindrical. *A. ferussacianus* (Lea) Bak.

Shell thicker, larger, subcylindrical.
A. ferussacianus var. subcylindraceus (Lea) Simp.

62.—*Anodonta*

Thin, inflated, with straight hinge line; umbones depressed.
A. imbecillis Say

Heavier, broader, umbones prominent.

Beaks with 5 coarse wrinkles; greenish. *A. grandis* Say

Beaks with 4 fine wrinkles; brownish. *A. footiana* Lea.

EXPLANATION OF MAP AND PLATES

EXPLANATION OF MAP

The squares bounded by full lines are sections, or square miles. The quarter sections are marked by dotted lines (half section lines). The shaded areas represent the original forest areas.

EXPLANATION OF PLATE I

Fig. 1 — The Lookout, west of the Laboratory, a gravelly mound. Looking south. Station 1 is marked.

Fig. 2 — West side of Laboratory grounds. Native prairie on which Station 2 was located. Looking north of west. Oct. 7, 1909.

Fig. 3 — A tongue of native prairie extending into the woods along a ridge just south of the Laboratory. Aug. 14, 1911.

EXPLANATION OF PLATE II

Fig. 1 — Looking north across Miller's Bay at the prairie hills beyond. The Laboratory grounds are on the wooded point. Aug. 14, 1911.

Fig. 2 — The ''trough'' west of the Laboratory, looking northeast towards the ridge shown in Fig. 1. The arrow shows the direction of the prevailing southwest winds. Oct. 7, 1909.

Fig. 3 — Elm Crest and woods, looking southeast at the abrupt northern banks of the peninsula. Aug. 28, 1911.

EXPLANATION OF PLATE III

Fig. 1 — Bur oak grove near Laboratory cottage. Station 3 was located near the lower left hand corner; station 4 was back of the tree marked 4. Looking southwest. Oct. 7, 1909.

Fig. 2 — The Laboratory pier and steps. Station 5 was located north of the steps, and is marked 5. A little strip of prairie runs down to this station from the northwest. Oct. 7, 1909.

EXPLANATION OF PLATE IV

Leaf sections of prairie xerophytes. The letters in the several figures represent the following structures:

a=Epidermis

b=Cutin

c=Water storage cells

d=Trichomes

The shaded cells are palisade cells.

The following species are represented:

Fig. 1 — *Liatris scariosa* Willd.

Fig. 2 — *Verbena stricta* Vent.

Fig. 3 — *Solidago rigida* L.

Fig. 4 — *Aster sericeus* Vent.

EXPLANATION OF PLATE V

Fig. 1 — Twin Mounds, looking southeast. Mr. Boot's stations I, II, III and IV, marked a, b, c, and d are represented on the southwest side. Aug. 26, 1911.

Fig. 2 — Bluffs on the west side of the Little Sioux river west and a little south of Milford, looking west of south. Trees appear only on the abrupt slopes. Aug., 1902.

Fig. 3 — Bowldery beach. East side of West Okoboji lake, north of Ft. Dodge Point. Aug., 1902.

EXPLANATION OF PLATE VI

Fig. 1 — Beach south of the Laboratory pier, looking north. Shows beach zones of vegetation, with bowldery beach in the background. The bare portion is almost daily washed by the waves. Aug. 25, 1911.

Fig. 2 — Sandy beach at the south end of Spirit lake, as it appeared at low water in August, 1902; in more recent years covered with water. A sandy prairie extends from this beach to the north end of East Okoboji lake. Looking northeast.

Fig. 3 — East shore of Center lake, looking north. Shows the disturbing effect of ice-shove: a=ice; b=sand; c=ordinary undisturbed beach. Dec. 8, 1911.

EXPLANATION OF PLATE VII

Fig. 1 — Marsh south of the hotel at Miller's Bay, looking south, as it appeared before the Beck canal was constructed. Aug. 28, 1911.

Fig. 2 — A part of East Okoboji lake above the drawbridge at Spirit Lake, as it appeared at low water in August, 1902. The plants are mostly *Sagittaria*. In recent years mostly clear water. Looking northwest from road.

Fig. 3 — A part of the same lake just above the drawbridge, looking towards the wooded bluffs in Spirit Lake. *Sagittaria* in foreground and mostly *Scirpus fluviatilis* along the shore. At low water in August, 1902. In recent years the foreground has been clear water.

EXPLANATION OF PLATE VIII

Fig. 1 — Kettleholes west of Lookout, near Laboratory, looking west. Oct. 7, 1909.

Fig. 2 — Border of kettlehole east of the Inn, showing both aquatic and marsh border vegetation. August, 1902.

Fig. 3 — Aquatic garden in Miller's Bay opposite the Laboratory, with the prairie hills shown in Plate II, fig. 1, in the background. Oct. 7, 1909.

ERRATA

In addition to obvious minor errors, such as improper use of itallics, punctuation, etc., there are clerical omissions of names of both plants and mollusks. These, with additional species, will appear in a supplementary report. The following more important corrections should be made:

Page 18, line 29,—"c" for "b".
" 19, " 24,—"somewhat" for "but little".
" 24, " 36,—"border" for "companion".
" 27, " 27,—"Teloschistes" for "Treloschistes".
" 31, " 42,—"Ait." for "Art."
" 44, " 25,—"dichotomum" for "dichtotomum."
" 52, " 24 and 26—"Sarcoscypha" for "Sarcosypha."
" 52, " 38—"Clavaria" for "Claviceps." Add author "Holmsk."
" 54, " 37—"crustulineforme" for "erustulineforme."
" 55, " 2,—"Mycena" for "Mycens".
" 59, " 42,—"Polygonatum" for "Polygonum."
" 64, " 22—add author "L."
" 69, " 12,—add "(See footnote 5, p. 15.)"
" 76, " 19,—" "2—3" for "2/3." "

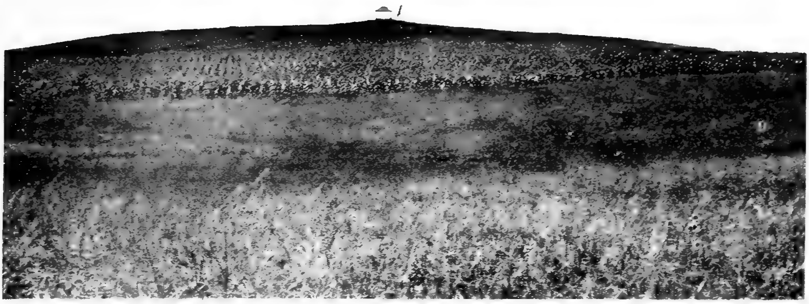


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.

Fig. 2.

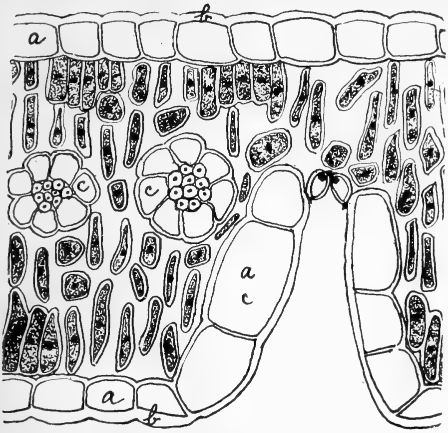
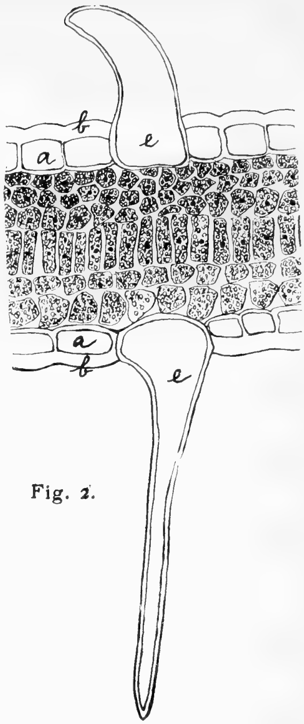


Fig. 1



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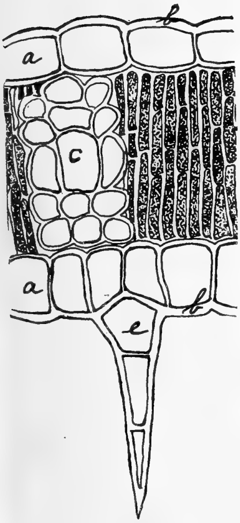

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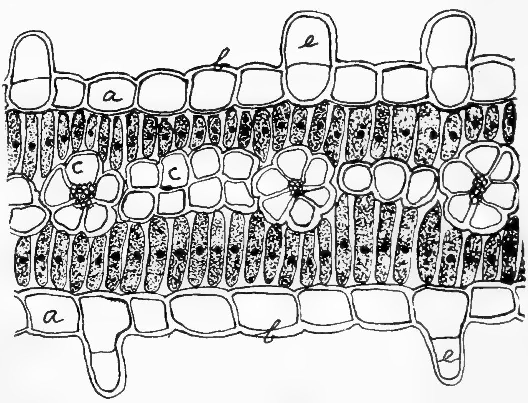

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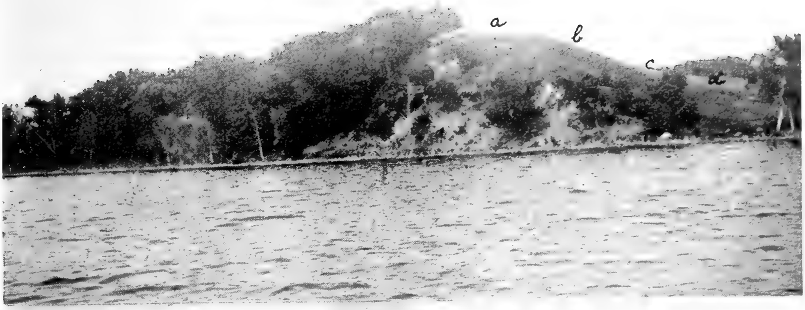

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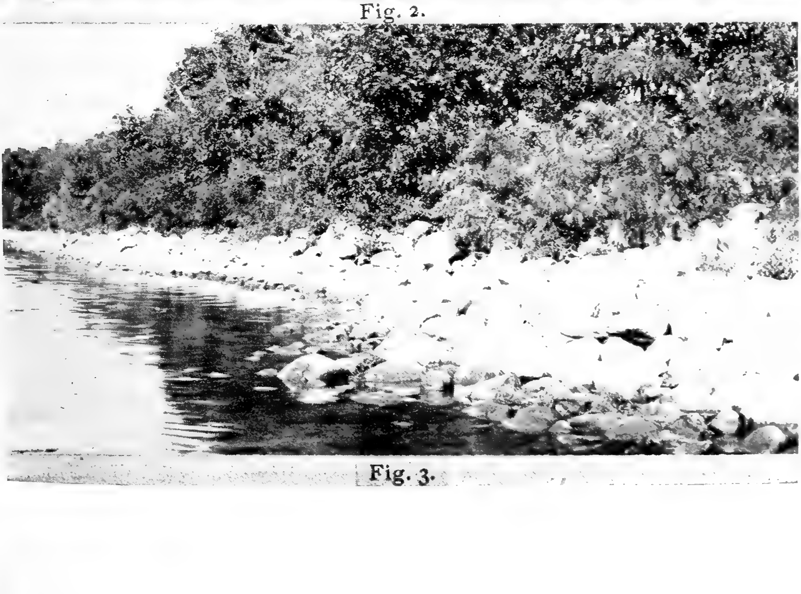

Fig. 3.

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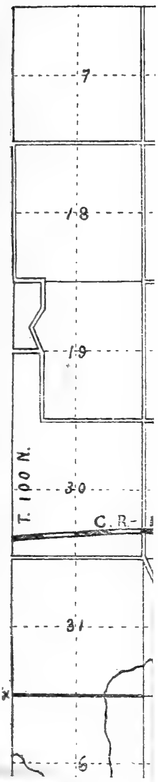
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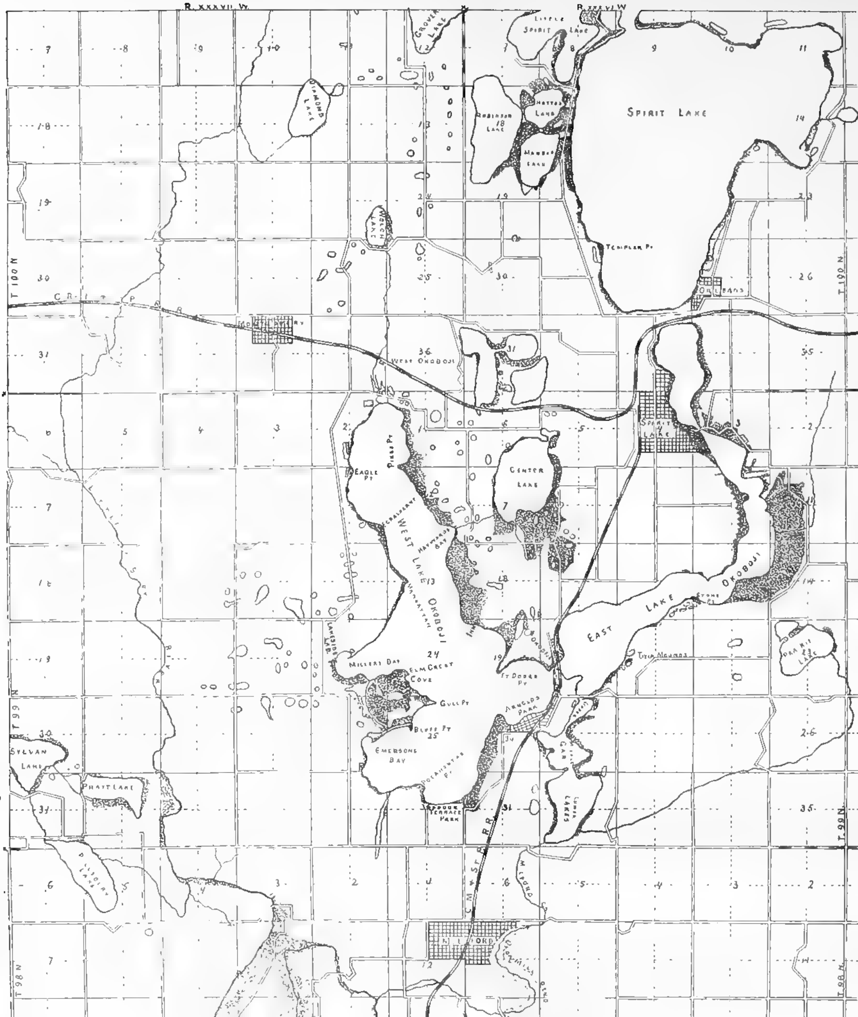

Map of the Lake Okoboji Region

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New Fossil Coleoptera from the Florissant Beds

BY

HENRY FREDERICK WICKHAM

PUBLISHED BY THE UNIVERSITY, IOWA CITY

ISSUED SEMI-MONTHLY THROUGHOUT THE YEAR. ENTERED AT THE POST OFFICE IN IOWA CITY AS SECOND CLASS MAIL MATTER

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BULLETINS FROM THE LABORATORIES OF NATURAL HISTORY

VOLUME VII NUMBER 3

CONTENTS

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PUBLISHED BY THE UNIVERSITY
IOWA CITY, IOWA

New Fossil Coleoptera From the Florissant Beds

Twenty-one species are described as new in the following pages. The Florissant list of Coleoptera now reaches a total of five hundred and fifteen, and while no new families are added several of the genera are either established as new or have not before been recognized from these deposits. Work on the available collections is now approaching completion and the ancient Coleopterous fauna of these Miocene shales may be considered as fairly well known.

It is quite within the bounds of probability that another year will see the publication of an analysis of the fauna which will allow of fairly accurate comparisons with local lists from various sections. Meanwhile it will not be altogether without interest to make a few general remarks as to the nature of the beetle life around the ancient Lake Florissant, as shown by the numerous collections, aggregating several thousand specimens, which have been studied by Scudder, Cockerell and myself.

Perhaps the most evident feature is the inconspicuousness of the majority of the species. It is true that a few large beetles occur, such as an occasional Calosoma, a Lucanus, a Strategus and so on, but there is nothing like the number of striking forms that one would expect when comparing the Coleoptera with the Mammalian life of the same period. In Iowa, California, New York or Canada, one might find in a single day more really fine beetles than are represented in the whole list of the Florissant fauna. There are no Pasimachus, Dytiscus, Hydrophilus (proper), Necrophorus, Al-

aus, Chalcolepidius, Chalcophora, Polyphylla, Cotalpa, Prionus, Monohammus and the like, among the hundreds of fossil species. Nor, in general, do we find evidence of much of the exaggerated specialization which gives variety to the study of recent forms, even from the more temperate climes. The natural and perhaps too obvious conclusion would be that the Coleoptera of this period were really much less specialized than those of today, and that the modern species of remarkable appearance, which look so out of place in our collections, are, in reality, late developments and not survivals from a past age. An alternative argument would be that the climate of Florissant during the period of shale deposition was too rigorous to allow great diversity of development in a group like the Coleoptera, which today responds so readily, with wonderful variety of form and structure, to a tropic life.

A discussion of the former thesis cannot profitably be held just now. As to the latter, it must be said that the abundance and variety of tree life, shown by plant remains, certainly indicates a mild climate, though not a tropical one. It also points to a moderate degree of humidity. Further, there is little in the makeup of the Coleopterous fauna, aside from the general tendency to inconspicuousness, to contradict the testimony of the flora. In fact there are some features, such as the enormous specific multiplication of the Curculionidae, the considerable number of Bruchidae and Rhynchitidae, the presence of types like Protapate and Chelonarium which, taken by themselves, would seem to point definitely to warmth. The matter is complicated by anomalous proportions in the representations of certain groups or families which are difficult of reconciliation with existing conditions.

One of these anomalies is well shown in the Scarabaeidae. At present, we have living in North America a very good representation of truly coprophagous genera and species, (Laparosticti), with a range as far north, at least, as the Great Lakes. As we go up the mountain sides, or to the far North, most of them disappear except the Aphodiini. But at Florissant, so far as our records show, were found no Canthon, Copris, Phanaeus, Onthophagus nor Geotrupes, genera common today in temperate climes. On the contrary, the Aphodiini were very plentiful, not in species

alone but in individuals. A second anomaly is noticed in the abundance of Byrrhidae, a northern characteristic in America nowadays, and a third is the very pronounced paucity of Chrysomelidae. Light may be thrown upon some of these problems when the Tertiary Coleopterous fauna of this country has been fully investigated. For the moment, all that can be done is to call attention to these phenomena, leaving their explanation to a fuller knowledge.

Because of the apparently close generic correspondence of the fossil beetles with species now living in North America, I am forced to believe that the insects of the Florissant Miocene stand in direct ancestral relationship to our present fauna, or that at worst they are closely collateral branches from a common stem. In most instances where the fossils are compared with modern forms, the specific affinities and the facies seem to be distinctively North American rather than European or Eurasiatic. It is presumable that North America received a large proportion of the species now inhabiting that part of the continent above the Sonoran zones from the Eurasian lands in some far distant time. It also seems likely that these immigrants would diverge more from the parental stock than those which remained in the original habitat. The Florissant fauna is sufficiently like the Eurasian of today to indicate a common general origin, but it is even more like that of recent North America and I see, at present, no reason to believe that it had been eradicated in anything like entirety, to be replaced by members of a fresh invasion from the north. The presence of a considerable number of southern types may be explained on the principle of an injection from centers of dispersal lying in that direction, or it is possible that they represent the remnants of a still more ancient fauna, occupying the Florissant site previous to the irruption of the Eurasian wave which gave the insect life its characteristic tinge.

Most of the specimens described in this article were collected by myself on the Wilson ranch, near Florissant, and the types, in such cases, are in my collection. Where another source or disposition holds, it is so indicated. All the figures are from my own camera lucida drawings on scales to suit the size or

nature of the subjects, and measurements must be taken from the text.

Arranged by families, the new species are:—

EROTYLIDAE.
Tritoma petrefacta

CRYPTOPHAGIDAE.
Cryptophagus petricola

NITIDULIDAE.
Miophenolia cilipes

MALACHIIDAE.
Malachius pristinus

PTINIDAE.
Oligomerus breviusculus

SCARABAEIDAE.
Lachnosterna (?) extincta

CERAMBYCIDAE.
Saperda florissantensis

RHYNCHITIDAE.
Rhynchites vulcan
Rhynchites laminarum
Eugnamptidea robusta

CURCULIONIDAE.
Apion florissantensis
Apion scudderianum
Ceutorhynchus blaisdelli
Baris antediluviana
Baris renovata
Baris nearctica
Miogeraeus recurrens
Centrinus hypogaeus

SCOLYTIDAE.
Pityophthoridea diluvialis
Adipocephalus hydropicus
Phloeotribus zimmermanni

TRITOMA PETREFACTA sp. nov.
(Plate I, Fig. 4).

Form stout, something as in the recent *T. unicolor.* Head, viewed from above, broader than long, front and vertex finely sparsely punctured. Eyes not well defined. Antennae slender basally and with the margins of the joints rather obscure, especially on the club which seems to be three-jointed, relatively longer and narrower than in the species with which it has been compared. Prothorax about two and two-fifths times as broad as long, much narrowed anteriorly, sides nearly straight, front angles acute, projecting forward, base broadly rounded, surface very inconspicuously punctured. Scutellum small but distinct. Elytra striatopunctate. Underside rather finely, sparsely and obscurely punctured except on the thoracic side pieces where the sculpture is much coarser and stronger. Legs wanting. Length 5.50 mm.

Described from one specimen, with counterpart.

Compared with the other Florissant species of this genus, the beetle is much larger than *T. submersa* and of a different shape from *T. diluvialis.* The remaining species, *T. materna,* is considerably smaller than *T. petrefacta* but on account of its being preserved in profile one cannot make satisfactory comparisons as to form. Compared with recent American species of Erotylidae, I find that *T. petrefacta* approaches *Mycotretus* and the

shorter species of *Tritoma* in form and sculpture but differs from them in having a narrower and carinate prosternum. Likely enough generic differences existed but none are available for use. The underside of the fossil shows the elytral striation, which has set through, much better than the upper. In the figure, I have merely indicated the courses of the striae by means of dotted lines and have not attempted to show the relations of the separate punctures.

CRYPTOPHAGUS PETRICOLA sp. nov.

(Plate I, figs. 1, 2).

Form elongate, subparallel. Head nearly twice as broad as long, strongly punctured, rather coarsely and closely upon the vertex, more finely and sparsely upon the front, anterior margin prominent at middle. Eyes of moderate size, coarsely granulate. Antennae with very large first joint, the second considerably smaller, third and fifth each nearly as long as the second but narrower, fourth, sixth, seventh and eighth shorter, ninth to eleventh forming a pronounced and rather broad club. Prothorax nearly twice as wide as long, punctuation about as coarse as that of the head, scattered on the disk, closer at the sides, the latter gently rounding and apparently not toothed. Elytra fully three times the prothoracic length, sides subparallel, punctuation about equal in size to that of the prothorax, not arranged in regular striae but showing some signs of serial arrangement. Beneath, head and prothorax rather coarsely and closely punctured, metathorax less so, abdominal segments nearly smooth. Length, 2.65 mm.

Described from one specimen, with which are associated two others.

Compared with the other Florissant fossil species, this is intermediate in size between *C. bassleri* and *C. scudderi* and differs from both in the antennal structure which is quite typical of recent species in the enlarged first and second joints.

MIOPHENOLIA gen. nov.

Form not very unlike that of *Phenolia,* mentum and mandibles, as far as can be seen, of the same type. Elytra nearly, if not quite, covering the pygidium. Legs stouter than in *Phenolia,* the middle tibiae rather strongly curved on the posterior margin which has a submarginal row of close, moderately long spines or stiff hairs. Elytral sculpture coarse, punctatostriate.

Type. M. cilipes sp. nov.

MIOPHENOLIA CILIPES sp. nov.

(Plate I, fig. 3).

Form, as preserved, a little more elongate and less parallel than in the recent *Phenolia grossa.* The specimen is exposed so as to show the underside and most of the characteristic sculptural features are therefore obscured.

Mandibles projecting, moderately long. Mentum bluntly angulate anteriorly in the middle, its face rather coarsely but not deeply punctured. Prosternum strongly separating the coxae, its sculpture and that of the remainder of the underside obscure but certainly not deep. Elytra exposed only on the edges and showing from beneath but exhibiting portions of two or three close rows of large punctures, rounded in form and separated by much less than their own diameters. Legs short and stout, the middle tibiae, which are the best preserved, each showing a row of close, rather long spines along the posterior edge. Length, 6.00 mm.

Described from one specimen.

Numerous characters are shown which point to the Nitidulidae as a family reference. These are the general form, prominent mandibles, capitate antennae (which, however, are poorly preserved), form of the mentum, position of antennal grooves, transverse front coxae separated by the moderately wide prosternum, non-truncate elytra and short legs with fringed tibiae. The beetle is above the average size of recent Nitidulidae but no larger than *Phenolia grossa* with which it has been compared.

MALACHIUS PRISTINUS sp. nov.

(Plate IV, fig. 26).

Form, as preserved, more elongate than in recent species of this genus, but from the position in which the specimen lies and the condition of the edges it is probable that the full width is not shown. Head of moderate size. Eye rather large, rounded. Antenna imperfectly preserved but showing about six rather long pectinations fairly well, from which it may be inferred that the individual was a male. Prothorax too badly crushed for description. Elytra about three and one-half times the prothoracic length, finely roughened and with some scattered punctures showing in places. Abdominal segmentation about equal. Legs wanting. Length, from front of head to elytral apex, 4.75 mm.

Described from one specimen.

Undoubtedly a *Malachius* or an allied type and, in a general way, similar to the living American forms of that genus. These very soft and fragile insects are seldom very well preserved and the present specimen is not perfect enough to allow of more specific comparisons.

OLIGOMERUS BREVIUSCULUS sp. nov.

(Plate I, fig. 6).

Form moderately elongate, the insect as a whole one and five-sixths times as long as wide. Head bent under the pronotum, front extremely minutely, closely and moderately deeply punctured and alutaceous. Eyes circular, separated by about twice their own width. Antennae not shown in detail.

Pronotum punctured about like the head except on the middle area where it is extremely minutely but distinctly and sparsely granulate, the granules scattering, not arranged in rows. Elytra evenly and minutely punctulate like the head, not striate excepting possibly one or two lines near the outer margin. Underside with small, close, vague, shallow punctures a little larger than those of the head. Legs short. Length, exclusive of extruded sex organ, 4.85 mm.

Described from one specimen with counterpart.

Compared with the described Florissant fossil Anobiinae, this beetle separates from all of them by the broad form, circular eyes and type of sculpture. As to affinities with recent forms, it appears to belong to LeConte's subgroup 2, Anobia, by the strongly deflexed head, resting upon the under surface of the prothorax. The first ventral seems not to be excavate for the reception of the hind legs, the metasternum neither excavate nor lobed in front. This is as far as the analysis can be carried through the generic table since the antennae are not well shown, but the non-clavate thighs, lack of hairy vestiture, separate abdominal segments and nonstriate elytra appear to exclude *Ptinodes, Hadrobregmus, Gastrallus, Trichodesma* and *Nicobium.*. The antennae are seen to lie on the front coxae, which are contiguous or nearly so. My opinion, therefore, is that the beetle belongs with *Sitodrepa* and *Oligomerus,* agreeing with them in the large eyes, as well as in the other characters noted. It differs from *Sitodrepa* in having the middle coxae absolutely contiguous, but agrees with *Oligomerus* in that particular. The finely punctate non-striate elytra, however, are foreign to the latter genus, as far as my experience goes.. Relatively to the head and prothorax, the present species has a much shorter hind body than the Florissant *O. (?) duratus,* which has a similar, though not identical type of sculpture. Quite probably the two are congeneric, even if not truly belonging to *Oligomerus.*

LACHNOSTERNA (?) EXTINCTA sp. nov.

(Plate I, fig. 5).

Represented by a wing cover only, in good preservation. It is very finely and deeply but sparsely and somewhat irregularly punctured, the punctures partially outlining four smoother areas which correspond to the costae seen on the elytra of many recent *Lachnosterna.* Along the sutural margin is a strong stria while the outer margin towards the apex has a much less

pronounced mark of the same character. Length, 15.65 mm.; width, at basal third, 6.30 mm.

Described from one specimen collected by one of the expeditions under Professor Cockerell, but without special designation of station. The type is in the Museum of the University of Colorado.

The generic reference is provisional. It is about the size of the recent *L. ulkei,* but the punctuation is sparser and a little more regular than that on any *Lachnosterna* with which I am acquainted.

SAPERDA FLORISSANTENSIS sp. nov.

(Plate IV, figs. 20, 21, 22, 23).

The specimen is so much crushed that the general form is obscured, but judging from the elytra it must have been somewhat less elongate than the recent American *S. calcarata.* Head not showing any details. Antennae preserved in part, the basal joint thick and heavy but as the base is hidden the relative length cannot be made out. Second joint very short, broader than long, third evidently but not greatly longer than the fourth, the three following subequal, none much enlarged apically nor hairy. Prothorax too poor for description. Legs moderately slender, the tarsus showing well on only one, which seems to belong to the middle pair. In this, the first and last joints are subequal in length, the second and third joints much shorter, the third moderately lobed. Elytron in good preservation, subparallel, about three and two-thirds times as long as the basal width, sculpture a coarse and close granulation or punctuation, heaviest just behind the base and fading out rather rapidly (though not to complete smoothness) at about the apical third. There is no visible color pattern. Length of elytron, 11.00 mm.; width across base, 3.00 mm.

Described from one specimen, with counterpart, collected by Mr. Geo. Wilson.

Compared with the three Florissant fossil forms of more or less similar size and relationships, this insect may be told from *Protoncideres primus* by the coarse elytral sculpture; from *Saperda submersa* by the lack of elytral band; while from *Parolamia rudis,* which seems to have been similarly sculptured, it separates by the smaller size and relatively more elongate elytra. In general, the structural and sculptural characters agree well with Saperda.

RHYNCHITES VULCAN sp. nov.

(Plate II, fig. 8).

Form, in profile, rather elongate. Head almost entirely covered up by a leg which is folded across it. Beak practically straight and equal, striate. Eye not large, circular or nearly so. Antennae long, inserted about the

middle of the beak, basal joints slender, club not compact, the two joints which show not broad. Prothorax very little arched along the back, surface shining with a few shallow punctures of small size which become more pronounced and rugose along each side near the middle of the hind margin. Elytra two and two-thirds times the prothoracic length, shining like the prothorax but not quite so strongly, showing only a few shallow punctures, clothed with rather short not very close fine hairs, no evidence of striae. Under side of body hardly visibly punctured even under high power. Legs long, distinctly hairy. Length, exclusive of rostrum, 4.00 mm.; of elytron, 2.85 mm.; of rostrum, 2.00 mm.

Described from one specimen.

Not much like any of the other Florissant Rhynchitids which approach it in size. *Auletes wymani* has strongly striate elytra, *A. florissantensis* is larger and differently sculptured. The species of *Docirhynchus* are differently proportioned. As matters stand, the only reasonable course seems to lie in describing this species as distinct and assigning it to a genus where, at any rate, it will not look much out of place.

RHYNCHITES LAMINARUM sp. nov.

(Plate II, fig. 7).

Form fairly elongate. Head long, tapering, shining, hardly perceptibly punctured, corrugate on the cheek behind the eye. Beak, measured from the eye, as long as the head and prothorax together and considerably more than half as long as the elytra, not tapering except at base, very slightly arcuate, apparently punctured. Eye small, circular. Antennae not displayed. Prothorax with moderately arched dorsum, surface shining, weakly and distantly punctured, the punctures rather fine. Elytra not strongly arched dorsally, with poorly marked striae of punctures. Underside vaguely roughened as if by large shallow punctures. Legs poorly shown, rather long. Length, excluding rostrum but measured from its basal constriction, 3.60 mm.; of beak, measured from front of eye, 1.50 mm.

Described from two specimens, one in lateral view the other exhibiting the dorsum.

The characters seem to be those of *Rhynchites* and this beetle is certainly different from any Florissant species placed in the Rhynchitidae by Scudder or myself. It is a good deal like the figure and description of *Apion smithii* from Florissant, but that insect is larger, with a relatively shorter beak. I am inclined to think that *Apion smithii* and *A. exanimale* are both Rhynchitids and that *Toxorhynchus minusculus*, the type of Scudder's genus, is an *Apion*.

EUGNAMPTIDEA ROBUSTA sp. nov.
(Plate II, figs. 11, 12).

Form stout. Head (probably unnaturally) sunken into the prothorax, the front finely and very sparsely punctured. Beak fairly thick, tip broken, upper surface with a well marked carina between two grooves. Eyes not defined. Antenna pretty long, though the point of insertion is not surely enough marked to allow of definite statements of relative length, club four jointed. The five joints preceding the club are not in very good condition but seem to be short, not much longer than wide, basal joints not well enough preserved for description. Prothorax about four-fifths as long as wide, not perceptibly narrowed anteriorly, disk deeply but not coarsely and rather sparsely punctured, the punctuation becoming decidedly coarser and closer laterally. Elytra striatopunctate, quite distinctly near the base but obsoletely on the disk and towards the apex. Legs poorly preserved, front pair (at least) long, the anterior femur strongly punctured and margined by a bead on both edges. Length, from front margin of pronotum to elytral tip, 3.20 mm.

Described from one specimen.

Rhynchitid characters are seen in the straight antennae with narrow, loose club, the long legs and the elytral sculpture. None of Scudder's species are much like this beetle, which approximates, in antennal structure, *Eugnamptidea tertiaria* from these shales. That insect is smaller, differently sculptured and has more slender antennae.

APION FLORISSANTENSIS sp. nov.
(Plate II, fig. 9).

Form stout, moderately ventricose. Head of moderate size, fairly closely and closely punctured, beak, measured from the front of the eye, about one-fifth longer than the prothoracic dorsum, only very slightly curved, not tapering, more roughly sculptured than the head with coarse punctures which tend to become confluent longitudinally so as to form indistinct striae. Antennae not defined. Eye roughly subcircular, lenses large. Prothorax arched above, though not strongly, not far from twice as high as long, punctuation coarse and close, more pronounced than that of the head. Elytra with deep striae, about as wide as the interspaces, strial punctures strong, rounded, separated by approximately their own diameters. Body beneath coarsely and closely punctured, more weakly on the abdomen. Legs fairly stout and not much elongate, femora not strongly thickened. Length, from pronotal front margin to elytral apex, 1.55 mm.; of head and rostrum, .75 mm.

Described from one specimen with counterpart.

Its minute size easily distinguishes this weevil from any of the other Florissant fossil species except *A. pumilum*. From that insect, it differs in having a much shorter head and by the pro-

thorax being more cuneate in side view. The sculpture seems to be about the same in both. In the present specimen there is still evidence of fine pubescence on the elytra, while the front and middle tibiae are closely clothed with minute hairs, directed longitudinally. All the femora are transversely finely wrinkled or striate, those of the front and middle legs more plainly.

APION SCUDDERIANUM sp. nov.

(Plate III, fig. 17).

Form fairly elongate, back not much arched except posteriorly. Head, measured from the front of the eye, more than two-thirds the length of the prothorax, strongly tapering, moderately coarsely and, in general, closely but not quite regularly punctate above the eye, finely striate beneath. Beak, measured from the same place, only a trifle longer than the prothorax, not tapering, except near the tip, regularly and gently curved, almost perfectly smooth. Eye elliptical, a little oblique, not very distant from the front margin of the prothorax. Antennae not defined except what is probably a bent portion of the scape lying upon the beak. Prothorax about one and two-thirds times as high as long, moderately tapering anteriorly, back pretty strongly and regularly arched, punctuation deep, moderately coarse, close and regular. Elytra not strongly convex on the dorsum except near the apex, striae deep, barely visibly punctate basally, interspaces hardly wider than the striae, transversely a little wrinkled. Sculpture of the underside weak. Legs not shown except one fore femur which is long and moderately stout but is not included in the figure. Length, exclusive of rostrum, 2.80 mm.

Described from one specimen with counterpart.

By the description and figure, this would come close to *Apion refrenatum* from the Florissant shales, but the present species is larger, has a much shorter beak and elliptical instead of circular eyes. The two short intermediate abdominal segments show very distinctly and have influenced my generic assignment.

CEUTORHYNCHUS BLAISDELLI sp. nov.

(Plate III, fig. 15).

Form moderately robust. Back, in side view, not strongly arched. Head with ill defined sculpture. Beak fairly stout, curved, about equal in length to the head and prothorax united, distinctly but finely striate and punctate. Eyes small, rounded. Prothorax about two-thirds as long as high, tapering anteriorly, without defined tubercles or spines, surface uniformly moderately coarsely cribrately punctured. Elytra subtruncate at apex, deeply striate, each stria with a row of small, well separated, rounded punctures, interstitial areas convex, each with about sixteen tubercles, low and flat near the elytral base but high and pointed apically. These tubercles are nearly

or quite coincident with the strial punctures in regard to number and spacing. Thoracic side pieces strongly, deeply and confluently punctured, metasternum a little less coarsely and much more sparsely. Abdominal punctures at base a little smaller, shallower and sparser than those of the metasternum, those of the apical segments apparently nearly obliterated. Legs of moderate length, the femora all distinctly punctured. Length, from base of beak to elytral apex, 2.20 mm.

Described from one specimen with counterpart.

Smaller than any of the Florissant fossil species described by Scudder and of totally different sculpture, which is of a type found in the recent group containing *C. hornii, C. nodipennis* and *C. adjunctus,* all from California, Utah and Nevada. I do not find evidence of scales upon the fossil and it may have been nearly glabrous like the first of the above species. The lateral tubercles were probably blunt or small since no indications of them remain.

The name is given for my friend Dr. Frank E. Blaisdell Sr., of San Francisco, well known for his work on the American Tenebrionidae.

BARIS ANTEDILUVIANA sp. nov.

(Plate IV, figs. 24, 25).

Form stout, oval. Head rather small, closely and fairly coarsely but not deeply punctured. Rostrum gently curved, equal in length to the prothorax, punctate about like the head and striate. Eye of good size, higher than long. Antennae not defined. Prothorax nearly twice as high as long, strongly tapering anteriorly and with well defined collar, back well arched, punctuation a little coarser than on the head, deep and close, each puncture with a small central mark which may be due to a scale. Elytra arched, strongly striate, the striae separated by about twice their own width, each with a row of more or less circular or slightly elongate punctures which are fairly deep and separated by approximately their own longitudinal diameters, interspaces not punctured. Metasternum punctured almost exactly like the prothorax, the abdomen much less strongly and deeply. Legs of moderate length, not very well preserved except one belonging to the front pair which has a broad femur and very slightly curved tibia, the latter rather coarsely punctured. Length, excluding rostrum, 2.50 mm.

Described from one specimen with counterpart.

In size, this is pretty close to several other Florissant Barids, but may be distinguished from all which approach it in this respect by the combination of characters shown in the relative length and height of the body, the strongly tapering and heavily punctured prothorax and the nature of the striation and punc-

tuation of the elytra. As the outline drawing is made from the slab which does not properly show the shape of the fore leg, a detail figure is given to illustrate this character.

BARIS RENOVATA sp. nov.

(Plate IV, fig. 19).

Form rather stout. Head unnaturally extended in flattening, so as to appear larger than normal, occiput (probably where overlapped in life by the pronotum) extremely minutely longitudinally closely rugose by confluence of the fine punctuation, vertex moderately coarsely, strongly and very closely punctured. Eye rather large, circular. Beak with outline poorly defined, sculptured a little more finely than the vertex, the punctures tending to become longitudinally confluent. Pronotum not much arched, punctuation coarse, moderately deep and as close as possible without confluence. Elytra but little arched along the back, with rows of moderately deep and large rounded punctures, each of which bears a short bristle or hair-like scale, the areas between the rows about smooth. Body beneath punctured in a manner similar to that of the pronotum except that there is a smooth area between the middle and hind coxae and the abdominal sculpture is less deep than that of the prothorax. Legs fairly stout and of moderate length. Length, exclusive of rostrum, 2.10 mm.

Described from two specimens with their counterparts.

This is referred to *Baris* in the wide sense because I am not able to assign it to any of the modern genera created by the dismemberment of the old group and at the same time no characters seem to offer themselves for the establishment of a new genus. Its form is very much that of some of the recent species of *Limnobaris* but the sculpture and vestiture are more like *Pachybaris porosus*. The abdomen is damaged so that the sutures are neither fully displayed nor distinct, but the pygidium seems to have been exposed. None of the other Florissant Barini are so small as this fossil which is unique, also, in punctuation and vestiture. The hairs are visible only in certain lights and must be sought for carefully under fairly high magnifying power.

BARIS NEARCTICA sp. nov.

(Plate IV, fig. 18).

Form rather elongate, subparallel. Head strongly and closely but rather finely punctured, the beak somewhat less distinctly. Rostrum but very little curved, nearly as long as the prothorax. Eye small, elliptical, its long axis oblique to the head. Antenna not well defined, but the club is pretty distinct and is elongate oval, pointed at the tip. Prothorax very deeply punctured, more coarsely than the head, the punctures extremely close together but scarcely confluent, finer along the front margin. Elytra long,

two and two-thirds times the length of the prothorax, punctatostriate, the rows of punctures as wide or wider than the interstitial spaces which are convex and extremely minutely punctulate. The strial punctures are circular or a little elongate, very deep and separated in general by less than their own diameters. Thoracic side pieces and metasternum a little less strongly punctured than the pronotum. Abdomen not displayed. Legs rather long, closely but not very strongly nor coarsely punctate on the femora and tibiae, none of which seem to be armed. Length, exclusive of rostrum, 4.50 mm.

Described from one specimen.

A baride weevil, more elongate than usual with *Baris* proper and reminding one, by its form, coarse sculpture and antenna, of the recent *Onychobaris mystica* from Utah and Arizona. It is apparently not like any of the Florissant weevils described by Scudder but approaches in size three of the fossil Barids which I have characterized. From *B. florissantensis* it differs in being much more coarsely punctured and in lacking distinct transverse markings on the elytral interspaces; from *B. cremastorhynchoides* in the very much larger elytral punctures which are nearly or quite as wide as the interstitial spaces, while in *B. cremastorhynchoides* the rows are separated by twice their own diameters, more or less; and from *B. schucherti* in the rows of elytral punctures being much more closely approximated so that the interspaces are narrower.

MIOGERAEUS gen. nov.

Body similar in form to *Geraeus*. Eye circular or nearly so. Intermediate abdominal segments short, sutures straight. Elytral striae largely confluent at base.

Type. M. recurrens sp. nov.

MIOGERAEUS RECURRENS sp. nov.

(Plate III, fig. 14).

Preserved in side view. Body stout, oval. Head, as preserved, sunken into the prothorax so as partially to obscure the eye, punctuation strong, extremely close and moderately coarse, but not confluent. Beak, measured from the eye, longer than the prothorax, base punctured like the head, tip more finely, in outline gently curved, nearly equal in diameter from the base to about the apex. Antennal scrobe well marked, antenna not preserved except a portion of the base. Prothorax about one and two-thirds times as high as long, strongly tapering to apex and with some evidence of a smooth collar, surface more coarsely punctured than the head but in similar fashion, dorsum gently arcuate. Prosternum with two short horns as in many modern males of *Geraeus*. Elytra moderately arched dorsally,

apex (judging from the striae) broken off, striae extensively confluent basally (though less deep in this region) as shown in the figure, moderately deep and narrow, sparsely punctate at bottom, the punctures small and nearly round, interspaces broad, flat, nearly smooth except near the base where they are somewhat wrinkled transversely or imbricately sculptured. Under side of body punctate similarly to the prothorax except that the abdominal sculpture is a little finer on the proximal segments and much more so on the distal ones. Legs in poor condition, moderately long. Length, excluding rostrum, 3.15 mm.

Described from one specimen.

Remarkable as showing the prosternal horns so characteristic of male *Geraeus* today. In this species they are shorter than in the majority of the Mexican forms figured by Mr. Champion but are pretty nearly in the same stage of development as in *G. marginatus.* I have felt obliged to separate the fossil under a new generic name on account of the peculiar elytral striation which I do not find paralleled in any of the Barini at my disposal. The appearance is almost as if the elytron had been turned end for end, but I cannot believe that such an accident could happen without leaving evidence of dislocation. I have made no account of the spur-like process on the front edge of the prothorax under the eye, not knowing whether it is adventitious or otherwise. It does not look like the sternal spurs. Compared with Florissant fossil Barini, this would approach in size *Catobaris coenosa,* which has longer legs, and *Aulobaris damnata* which has a shorter beak. Both are entirely different in elytral sculpture.

CENTRINUS HYPOGAEUS sp. nov.

(Plate III, fig. 13).

Form stout, outline, in side view, oval. Head strongly, closely and fairly coarsely punctate on the vertex, cheeks very finely corrugated. Beak, measured from the eye, a little longer than the prothorax, gently curved, finely striate, otherwise nearly smooth. Eye elliptical. Antennae too poorly shown for description. Prothorax hardly arched along the back, strongly tapering anteriorly, punctuation regular, somewhat coarser than on the head, close and strong, each puncture roughened at bottom, possibly by the presence of a scale. Elytra regularly and fairly deeply striate, the striae with distinct, but not very strong, subcircular, well separated punctures, interstitial spaces broad, flat, about twice as wide as the striae. The elytra appear to have been covered with a moderately close, fine, hair-like vestiture. Sterna sculptured about like the prothorax but perhaps a little more coarsely, punctuation of the abdomen similar at base becoming finer

apically. Legs of moderate length, finely roughened, possibly by hair marks. Length, exclusive of rostrum, 3.00 mm.

Described from one specimen with counterpart.

By all the visible characters, this seems to be a good *Centrinus.* The elytral striation will separate it at once from *Miogeraeus,* while the longer beak and different form of body will distinguish it from *Aulobaris damnata.* It is not especially likely to be mistaken for any of the other Florissant fossils.

PITYOPHTHORIDEA gen nov.

A name proposed for a fossil insect of the same general form as the recent *Pityophthorus* and with similar sculpture but having the intermediate abdominal segments less shortened.

Type. P. diluvialis sp. nov.

PITYOPHTHORIDEA DILUVIALIS sp. nov.

(Plate IV, figs. 27, 28).

Form moderately elongate, nearly parallel. Head crushed and partly obliterated. Prothorax projecting over the head, dorsum a little arched and with about six transverse rows of asperities which look like the raised edges of large subconfluent punctures. Elytron about one and two-thirds times the length of the prothorax, with rows of punctures not very well preserved but evidently large and only fairly deep. Legs short, rather stout. Length, from front margin of prothorax to elytral apex, 2.40 mm.

Described from one specimen, with counterpart.

Looks very much like a *Pityophthorus,* but is shorter and stouter than the average in this genus. The print on one slab shows a portion of the abdomen very well and it is on account of the somewhat greater length of the intermediate segments that I have proposed a new generic name.

ADIPOCEPHALUS gen. nov.

This name is proposed for an insect probably belonging to the tribe Scolytini, by the ascending ventral surface of the abdomen, but with an enormous head which approximates the prothorax in size. The hind tibiae (at least) are broad and flat, femora stout. Body sculpture rough. The eye is not definable in entirety, but what shows of the upper margin indicates that it is broader and shorter than in the modern *Scolytus.* In general, the abdominal segmentation agrees with that genus but the surface was probably less strongly ascending in the fossil.

Type. A. hydropicus sp. nov.

ADIPOCEPHALUS HYDROPICUS sp. nov.

(Plate II, fig. 10).

Preserved in lateral view. Form stout, subparallel. Head extremely

large, almost as high as the prothorax and about two-thirds as long, vertex sloping into the front with a gentle curve. Cephalic punctuation minute but distinct and pretty regular, genae vertically finely rugose. Antennae obscured. Eye not fully definable. Prothorax subcuneate in side view, back scarcely arched, surface finely granulate on the disk, becoming closely, moderately coarsely and rather deeply punctate on the lower portions of the sides where the punctures tend to form vertical rows. There are no thoracic asperities. Elytra rather badly broken on the outer edge and probably with the sutural margin also wanting, but what remains shows the sculpture very well. This consists of moderately deep wide striae, coarsely but not very deeply punctate, the punctures nearly approximate. Interspaces broad, nearly flat, finely roughened. Metasternal area and base of abdomen closely and not deeply punctured, these punctures somewhat smaller and much less distinct than on the prothoracic flank. Legs short, stout. Length, 2.85 mm.

Described from one specimen.

A well preserved little insect which separates at once from all Florissant fossils of somewhat similar form and size by the combination of large head, short prothorax and strong sculpture.

PHLOEOTRIBUS ZIMMERMANNI sp. nov.

(Plate III, fig. 16).

Form elongate, nearly parallel. Head wanting except a small portion in poor condition. Prothorax strongly rounded anteriorly, subparallel behind, base almost rectilinear, surface roughly and rather irregularly punctured, the anterior edges of the punctures toward the front and sides strongly raised so as to form distinct asperities. Elytra imperfect as to outline, basal margin raised and serrate, each with seven rows of deep circular punctures which are pretty closely approximated longitudinally and wider than the rather shallow striae. Interspaces not quite equal in width, but broader than the diameter of the punctures, asperate like the prothorax though not quite so strongly, the asperities becoming lower and more transverse as they approach the elytral apex. Length, as preserved, 3.00 mm.

Described from one specimen.

In those characters which can be determined this insect approaches very closely to the recent genera *Phloeotribus, Phloeosinus* and *Polygraphus,* but I have finally decided to refer it to the first of these on account of its general similarity in sculpture to the modern *Phloeotribus frontalis,* found in the eastern half of the United States. The outer elytral edge is almost certainly broken off, so that I am unable to say whether or not it is serrate.

The name is given in memory of Christoph Zimmermann, an early and industrious student of American Scolytidae.

EXPLANATION OF PLATES

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Fig. 1. Cryptophagus petricola.
Fig. 2. Cryptophagus petricola, antenna.
Fig. 3. Miophenolia cilipes, underside.
Fig. 4. Tritoma petrefacta, underside.
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Plate II.

Fig. 7. Rhynchites laminarum.
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Fig. 9. Apion florissantensis.
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Fig. 11. Eugnamptidea robusta.
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Plate IV.

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Fig. 19. Baris renovata.
Fig. 20. Saperda florissantensis, elytron.
Fig. 21. Saperda florissantensis, leg.
Fig. 22. Saperda florissantensis, antennae.
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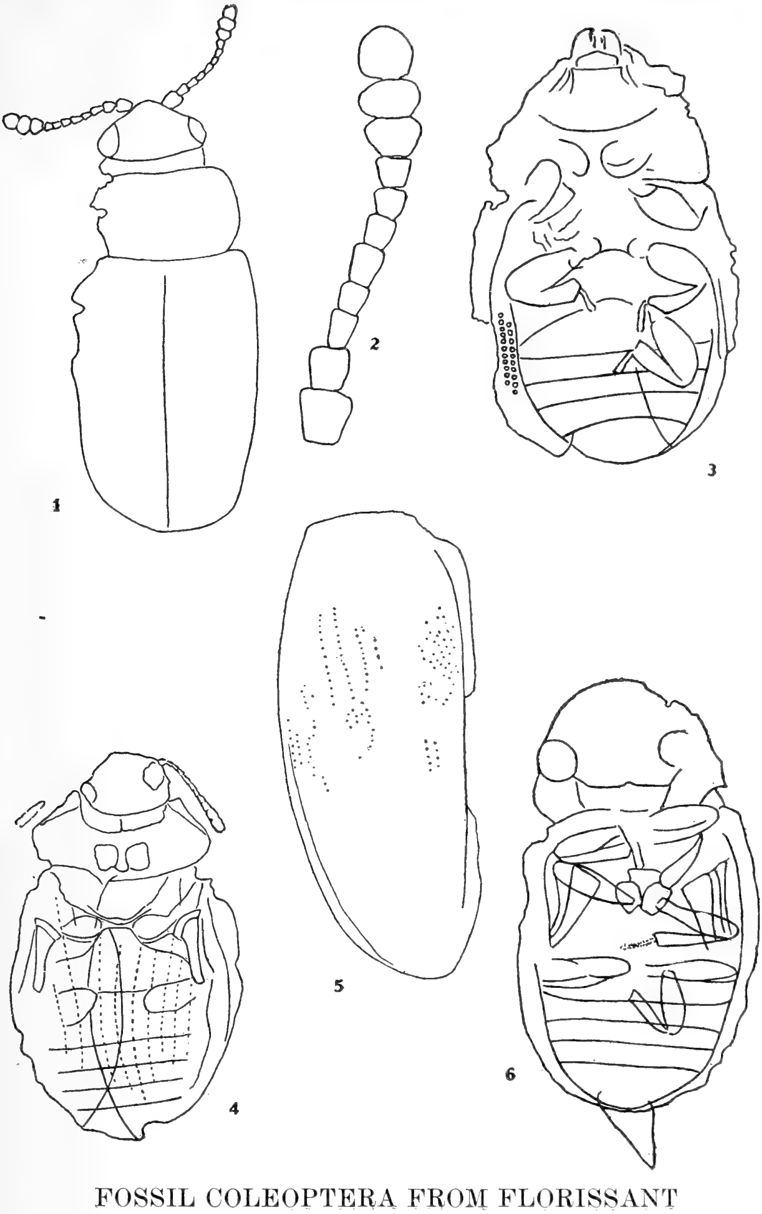
Fig. 24. Baris antediluviana.
Fig. 25. Baris antediluviana, fore leg.
Fig. 26. Malachius pristinus.
Fig. 27. Pityophthoridea diluvialis.
Fig. 28. Pityophthoridea diluvialis, abdomen and hind leg.

PLATE I

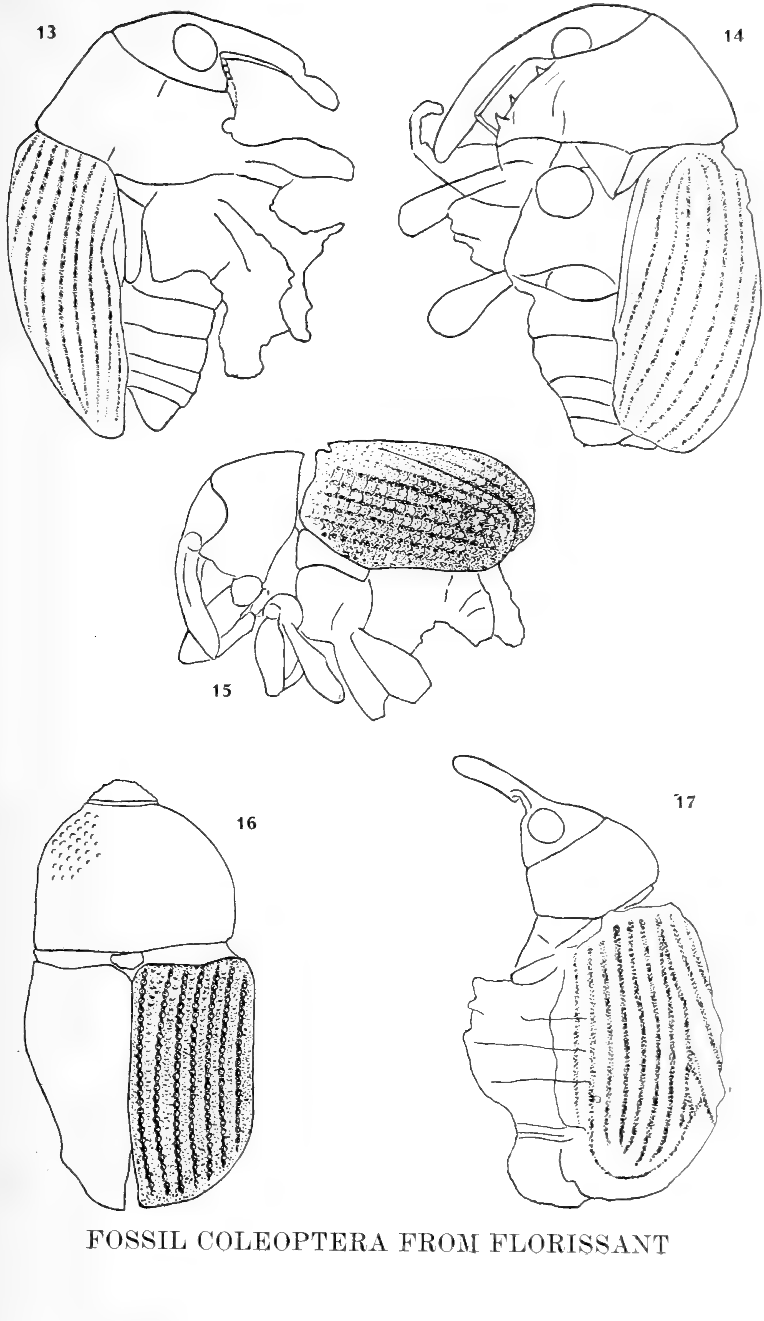


FOSSIL COLEOPTERA FROM FLORISSANT

PLATE II

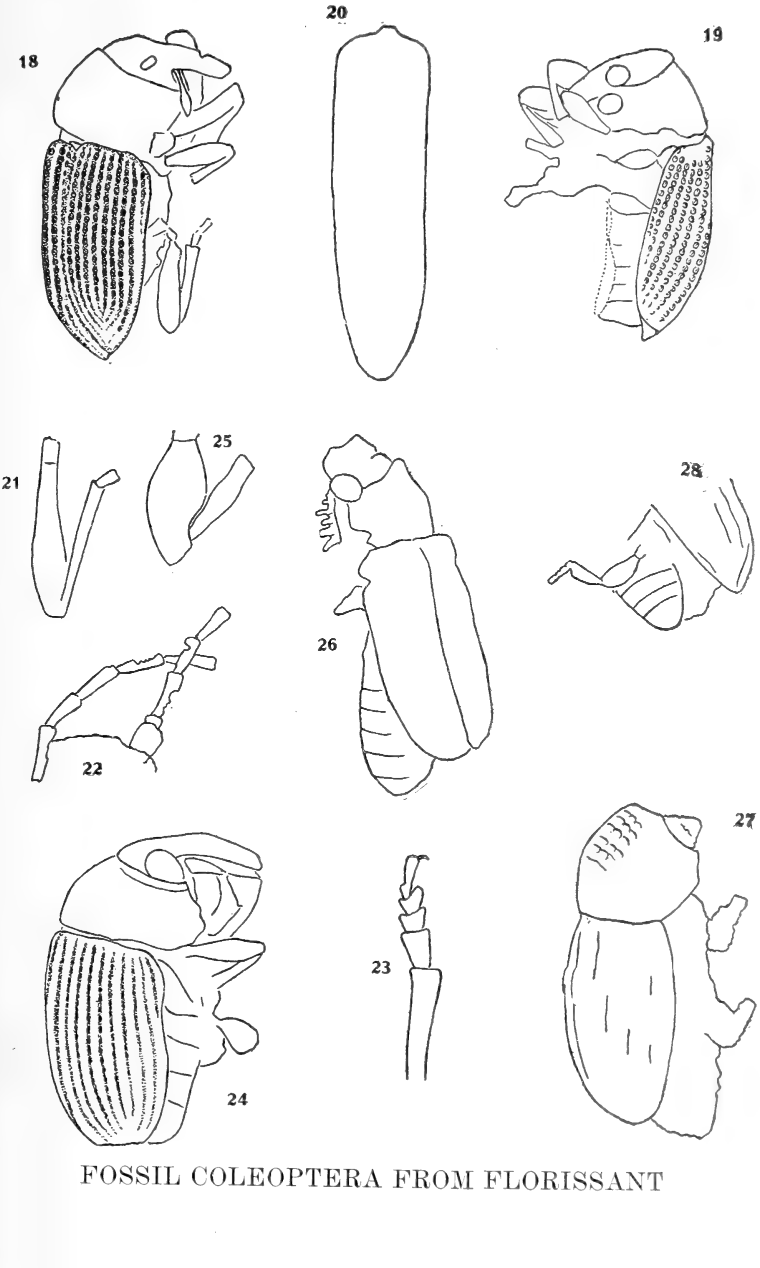
FOSSIL COLEOPTERA FROM FLORISSANT

PLATE III



FOSSIL COLEOPTERA FROM FLORISSANT

PLATE IV



FOSSIL COLEOPTERA FROM FLORISSANT

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Professor CHARLES C. NUTTING, Editor

VOLUME VII NUMBER 3

CONTENTS

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THE PLANT GEOGRAPHY OF THE LAKE OKOBOJI REGION: ADDITIONAL NOTES

By Bohumil Shimek

Since the publication of the Bulletin on the flora of the Lake Okoboji region[1] two years ago, field studies have been continued by several members of the staff of the Macbride Lakeside Laboratory, and papers by Drs. Stephens and Wylie, and Mr. Stoner which are a result of these studies, are included in this Bulletin.

The writer continued his observations on plant distribution in the lake region with some interesting results.

The summers of 1915 and 1916 were unusual in their meteorological conditions. The season of 1915 was exceptionally cool and moist, while that of 1916 was cool and moist in the spring, but hot and rather dry during the summer. The greater abundance of water rehabilitated many of the smaller kettleholes, some of which had entirely lost their earlier character, and their number is greater than is indicated in the forest map of the lake region published in the Bulletin cited, which represents the greater part of the kettleholes noticeable during the dry summers preceding that of 1914. The greater amount of moisture during these two years produced striking changes in the flora. Swamp and low ground species became much more abundant, and several species which are ordinarily found in low grounds were observed on the higher prairie west of West Okoboji lake. The most striking of the latter are the following, which may be added in the former Bulletin to the column numbered in the *Prairie list*, pp. 29-37:

Iris versicolor L. III

Habenaria leucophæa (Nutt.) Gray III

[1] Shimek, B. Bulletins from the Labs. of Nat. History, State Univ. of Iowa, vol. VII, no. 2, May, 1915.

Potentilla Nicolletii (Wats.) Sheld. III
Lycopus americanus Muhl. VII
Gerardia tenuifolia Vahl. IV
Boltonia asteroides (L.) L'Her. III, IV

Several aquatic and swamp species were added to the list. They should be inserted in the hydrophytic list, pp. 43-49:

Carex lanuginosa Michx. n, VI, 1; VII, 1.
Eriophorum angustifolium Roth n, VI, 2; VII, 3.
Lemna minor L. m, III, 1.
Cypripedium candidum Muhl. n, VI, 4.
Hippuris vulgaris L. n, IV, 4.
Gentiana crinita Froel. n, VI, 2.
Gentiana Andrewsii Gris. n, VI, 4.
Bidens laevis (L.) BSP, n, IV, 4.

Aquatic plants flourished, and some of the species, notably *Utricularia vulgaris var, americana,* occurred in unusual numbers. On the other hand *Vallisneria, Elodea,* some of the species of *Potamogeton*, etc., were not much in evidence, the high level of the water in the lake keeping them submerged. *Bidens Beckii,* usually abundant and with many of its heads raised above the water, was less abundant and remained entirely submersed, though flowering abundantly, excepting in the canal between Miller's Bay and Emerson's Bay, where occasional heads appeared above water. *Wolffia columbinana* Karst., added to the aquatic list, was very abundant in ponds connecting with the west side of West Okoboji lake. Numerous flowering specimens were collected in August. On the whole, the deeper water species of flowering plants suffered because of the higher level of water, while the marsh and low ground species were favored.

The two successive favorable seasons also produced their effect upon the flora of the prairies. The usual yellowish or brown color which marks the prairie slopes during the latter part of August was missing, for the vegetation remained fresh even through the hot days of July and August. *Stipa spartea* was so abundant on the knolls and upland prairies that it prevented fieldwork on the prairies for a week on account of the extremely abundant fruit. Several species which belong in the *Prairie list* were added during 1916, and they should be inserted in the earlier list in the columns indicated by number. Those marked "i" in that list are introduced species:

Humulus lupulus L. d, VIII, 3.
Medicago Lupulina L. i, VII, 4.

Helianthemum majus BSP. d, VII, 4.
Euphorbia glyptosperma Eng. e, V, 4.
Ceanothus ovatus Desf. a, III, 4.
Œnothera muricata L. e, V, 3.
Gerardia auriculata Michx. c, III, 2.

Several forest species of flowering plants were also added to the list. The following should be inserted in the *Forest list* in the columns indicated by numbers:

Dactylis glomerata L. i, VII, 4.
Habenaria bracteata (Willd.) R. Br. a, I, 5.
Populus balsamifera L. a, VI, 5. Evidently native.
Geum strictun Ait. a, V, 4.
Apios tuberosa Noench. c, VIII, 3.
Sanicula gregaria Bick. a, I, 2.
Galium palustre L. c, I, 3.
Viburnum pubescens (Ait.) Pursh. b, III, 3.

Many of the cryptogams were also favored by these seasons. Mosses, especially those of the woods, were more abundant than they had been in twenty years, and a very creditable list of additional species was secured. Parasitic fungi were also unusually abundant, and a goodly number of species has been added to the lists. Further collections of diatoms, lichens, etc., were also made. A report upon these groups is in preparation.

Observations on the sand-flora of the beaches were also continued, and the result is included in the accompanying report on the sand-flora of the state. These beach-floras also felt the effect of the greater supply of moisture, and the season of 1916 showed an increased number of low-ground species upon the beaches.

B. Shimek,
Director of the Macbride Lakeside Laboratory, 1916.

THE SAND-FLORA OF IOWA

By Bohumil Shimek

A relatively small portion of Iowa is covered with sand, yet there is a sufficient amount of it to offer opportunities for interesting ecological investigations. The sand and gravel surfaces are the least stable, and are often modified by the action of wind and water, thus offering fresh surfaces for the study of plant succession. In all probability, the changes which take place in the flora of our sandy surfaces today are essentially the same as those which occurred on the drift-surfaces after the recession of the glacial ice; but the floras of the latter have long ago reached the climax stages of their development, and are subject only to very slow changes.

With reference to their origin, rather than their flora, our sandy areas may be divided into five principal types:

1 — *Lacustrine beaches.* — These are illustrated by the sandy beaches at Terrace Park, along Emerson's Bay, and at the head of West Okoboji lake; by the beaches on the south, east, and north shores of Spirit lake, and the north shore of East Okoboji lake; by the east and northwest shores of Clear lake; and by sand beaches along some of our smaller lakes. These beaches usually grade from a low, new part near the water's edge, to a higher, older part now seldom, if ever, reached by the waves. The former is subject to frequent changes through the action of the waves in summer and ice-push in the winter, and is usually devoid of vegetation near the water's edge, as illustrated in Plate I, fig. 1.[1] It sometimes grades off into swamps, as on the north shore of Miller's Bay and of West Okoboji lake, but more frequently it passes through higher beach surfaces to ordinary prairie, as may be observed on the eastern shores of the northern part of Spirit lake, at Orleans, and at the northern and southern extremities of West Okoboji lake.

[1] See also "The Plant Geography of the Lake Okoboji Region," Bull. Lab. Nat. Hist., S. U. I., vol. VII, no. 2, plate VI, fig. 1, and fig. 3.

The materials of these beaches are usually sand and gravel, sometimes bowlders. In the latter case, the bowldery beach usually ends rather abruptly near the base of wooded banks.[2]

2 — *Fluviatile sands.* — These are the ordinary sand and gravel bars along our streams, and they also grade into higher, older bars or flats, now seldom reached by the waters of the stream excepting for a short period during high water. The materials on these shores also vary from fine sand to gravel and bowlders. Illustrations may be found along most of our streams, excepting the prairie streams of the western part of the state, the Cedar river furnishing the finest examples. See also Plate I, figs. 2 and 3.

3 — *Sand-dunes.* — The sand-dune areas of Iowa are quite limited and are practically restricted to two sections of the state: those along the Missouri river, chiefly in Harrison county; and those which lie chiefly in Muscatine county. The latter are in two distinct groups, one occupying a part of Muscatine Island and extending into Louisa county, and the other extending along the Cedar river valley, chiefly in the vicinity of Adams and Bayfield.

The Harrison county dunes[3] are typical low dunes, seldom reaching a height of 20 feet. They are formed from sands blown up from the bars of the Missouri river, and heaped up usually around clumps of willows or cottonwoods. They present various phases of development, some being almost bare (see Pl. II, fig. 1), and frequently shifting, others are densely covered with vegetation (see Pl. II, fig. 3), while still others present intermediate phases (as in Pl. II, fig. 2). The dunes frequently break down (see Pl. III, fig. 2), especially during dry, windy periods, and even the roots of trees may be exposed by the shifting of the sand, as shown in Plate III, fig. 3. The sand of these dunes is derived from nearby bars of the Missouri river.

The dunes of Muscatine county are less pronounced, somewhat scattered, and with the exception of portions of the north end of the Big Mound, mostly covered with well-established vegetation, though this is somewhat variable during different seasons. Three principal groups may be noted: — those on Musca-

[2] See ibid., plate V, fig. 3, and plate VI, fig. 1.

[3] See writer's brief description, with illustrations, in Iowa Geological Survey, vol. XX, pp. 411-412; 1910.

tine Island, forming a part of the Big Mound, derived principally from Mississippi river sands (see Pl. IV, figs. 1-3) ; — those which are found near Adams, in the bed of the glacial Lake Calvin, which are derived chiefly from the sands of the old lake bed; — and those which have encroached more or less upon the Illinoian drift-plain north and northwest of Bayfield (see Pl. V, fig. 1), which are probably derived in part from the bars of the Cedar river, and in part from the sandy margin of the Illinoian drift.

The dunes of the Muscatine region are largely fixed by a well-developed vegetation, but portions of all these areas become denuded at times, particularly during dry summers.

These dunes, like those of Harrison county, are made up of fine sand.

4 — *The ridge sands and gravels.* — These are more limited in extent, and are found in interrupted groups and patches, chiefly along the border of the Iowan drift from Hardin county eastward to the Mississippi and along the border of the Illinoian, where they blend in places with the dunes; and in limited portions of the Kansan drift area. Similar ridges are found along the border of the Wisconsin drift, especially northward in the state, and they are covered with a typical prairie flora.

These ridges owe their sand and gravel to the several drifts, and they are now mostly quite stable, and their flora blends with that of the adjoining prairie or forest.

5 — *The talus sands.* — These sands are very limited in area, and are restricted to the vicinity of the bases of scattered ledges of St. Peter Sandstone in the northeastern part of the stae. A small portion of such an area is shown in front of the ledge in Plates I-III, Vol. V of this series, following p. 224 (bis) ; 1904.

The several sand-areas are not sharply defined. The beach and bar areas blend with the prairie, swamp, or forest; the dune areas connect with the alluvial sands on the one hand, and with prairie and forest soils on the other; the ridge sands and gravels grade into prairie and forest; and the limited talus sands likewise soon pass into forest or prairie soils.

The Flora

This intergradation is also reflected in the flora, which sometimes shows an admixture of swamp species, and at others of

forest species, but usually blends most completely with the prairie flora.

The beaches of the Okoboji lakes and Spirit lake frequently show the intergradation of swamp and beach. On the newer parts which are subject to wave-wash, there is often a blending of low-ground or swamp species with those which habitually grow in moist, sandy places.

These species are marked "w" in the list, and those which were found on lake beaches are indicated in column I. Of the species so marked in this locality list, *Verbena hastata, Stachys palustris, Erigeron philadelphicum* and *Ambrosia trifida* are not uncommon on higher prairie.

A similar mingling of hydrophytic forms is noticeable in the Harrison county dune region, where pools and low, wet places are not unusual. The hydrophytic species which here appear on wet sand, and which mingle more or less with the ordinary sand-xerophytes, are also marked "w" and appear in column V of the plant-list.

The bars and sandy shores of streams also frequently show a number of these hydrophytic forms. Columns II and III of the plant-list contain such species, marked "w." The species of *Eragrostis* and *Hemicarpha* are very commonly the pioneers on river-bars.

A few species which usually occur in forested regions are also found on the lake beaches and river bars. They are marked "f" in the list.

The most common species which occur on the beaches and bars, especially where the vegetation has become quite well established, are prairie species. *Sporobolus cryptandrus, Cyperus Schweinitzii, Corydalis micrantha*, both species of *Polanisia, Strophostyles helvola*, and *Euphorbia glyptosperma* are the only species restricted to the sands of the lake beaches. Even *Cenchrus*, and *Strophostyles pauciflorus* are not restricted to sand, but often occur on the upland prairies of the western part of the state. All other species are essentially prairie species.

The true sand-species of the river bars are the same as those of the lake beaches, excepting that the *Euphorbia* has not yet been found on the former, which, however, contain the following additional species:

The several species of *Eragrostis*, commonly in wet places;

Cyperus filiculmis, Froelichia floridana, Mollugo verticillata (native?), *Corydalis aurea var., Corydalis curvisiliqua, Draba caroliniana, Cristatella Jamesii, Tephrosia virginiana,* both species of *Croton, Rhus canadensis var., Viola pedata,* the *Opuntia, Oenothera rhombipetala,* the *Androsace, Asclepias amplexicaulis, Phlox bifida, Lithospermum Gmelini, Monarda punctata,* and *Houstonia minima.*

Quite frequently forest species and introduced weeds find their way to the bars. The former are marked "f" and the latter "w" in the list.

The upland sands are often denuded by winds, less frequently by water. Various species of plants become established upon these fresh surfaces.

In the dune region of Harrison county, the *Leguminosae* such as *Cassia, Desmodium, Crotalaria, Dalea enneandra,* and *Strophostyles* are the first to appear, always with an abundance of root-tubercles containing nitrifying bacteria.

On the dunes of Muscatine county, the pioneers are *Mollugo,* the species of *Croton* and *Corydalis, Cyperus Schweinitzii* and *C. filiculmis, Cristatella Jamesii, Euphorbia polygonifolia,* and other prostrate species of *Euphorbia,* and these are soon followed by other sand and prairie species.

The Harrison county dunes present a limited number of sand-species not found in the other areas, — in fact but two: *Euphorbia dentata* and *Lygodesmia rostrata,* a rare western species. All other species not especially marked, are of the prairie type.

The Muscatine dune list of sand-plants is much larger. The following species, not found on the Harrison county dunes, are more or less characteristic of the dune and upland sands of Muscatine county:

Commelina virginica	Euphorbia polygonifolia
Polygonum tenue	Rhus canadensis var.
Cycloloma atriplicifolia	Opuntia Rafinesquii
Froelichia floridana	Oenothera rhombipetala
Mollugo verticillata	Synthyris Bullii
Draba caroliniana	Houstonia minima
Cristatella Jamesii	Aster linariifolius
Croton capitatus	

Other sand plants, already mentioned in connection with the other sand-areas, are also found in these dune areas, as may be

observed in the list. The greater part of this flora, however, as in all the sandy areas, consists of prairie plants, and where the dunes and upland sands become well established, the prairie flora takes complete possession, as is illustrated in most of the area represented in Plate V, fig. 3.

Sometimes the plant covering also passes into forest. The transition from bare dune, as shown in Plate II, fig. 1, through the series illustrated in figs. 2 and 3 of the same plate, to Plate III, fig. 1, may be observed in many places in the Harrison county area. The transition usually occurs from *Salix longifolia* and *Amorpha fruticosa*, of low grounds (see Plate I, fig. 3), and *Salix missouriensis, Cornus paniculata*, and *Zanthoxylum americanum* of the dunes, to *Populus deltoides, Salix amygdaloides, Acer negundo, Crataegus mollis* and *Ulmus americana, Populus* being the dominant species.

In the Muscatine dune region, a similar transition to oak forest may be observed. Plate V, fig. 1, illustrates this. The light spot on the fixed dune in the background shows a "blow-hole" with shifting sand. The only plants on portions of this are mats of *Mollugo verticillata* (see fig. 2 on the same plate); then follows a scattering of *Croton capitatus, Cenchrus*, and *Polanisia*; the vegetation then becomes denser and consists in part of sand-species such as *Oenothera rhombipetala, Cyperus Schweinitzii*, and *Carex cephalophora*, but chiefly of prairie species, such as *Panicum Scribnerianum, Amorpha canescens, Rosa pratincola*, and other typical prairie forms; then clumps of *Rhus canadensis var., Vitis vulpina*, etc., form a transition to the forest in the background, which consists of *Quercus velutina* at the margin, with other hard-wood upland species in the deeper forest.

The flora of the sandy ridges, listed in column VI does not differ in important particulars from that of the dune regions, excepting that there is a smaller number of typical sand-plants, and a more complete blending with surrounding prairie and forest floras.

The sand-talus flora is limited, and contains no species which does not occur in the other areas. The sand is quite sterile and the plants are mostly decidedly dwarfed.

The preponderance of prairie plants on these sandy and gravelly areas is of special interest because it demonstrates the fallacy

of the conclusion reached by Whitney [4] and others, that the flora of the prairies is determined by the fineness of the soil.

The tabulated list of plants which follows presents a comparative view of the flora as observed on the several sandy areas. It is not presumed that the lists are complete, but they well show the character of the flora. Perhaps column VI is the least complete, as it is very difficult to determine the limits of such areas. It should be stated that the collections on which this report is based are deposited in the Herbarium of the State University of Iowa.

It will be observed that the several areas, even when of the same type, do not show a uniformity of species. Thus the species common to II and III, the river sands areas, number 74; those found only in II number 70; and those found only in III number 85. The dune areas IV and V, from opposite sides of the state, have 45 species in common, while 167 are found only in IV and 42 only in V.

The total number of species listed is 397. Of this number 186 were found in the areas represented in column I; 148 in column II; 163 in column III; 217 in column IV; 88 in column V; 54 in column VI; and 19 in column VII.

According to habitat and habit, the species listed may be grouped as follows:

	I	II	III	IV	V	VI	VII
Prairie species	99	88	86	138	39	37	12
Species of open places, mostly prairie	7	9	8	13	5	6	2
Usually in sand, sometimes on prairie	7	5	16	13	9		
Dry sand species	9	15	22	28	6	3	2
Wet sand or marsh species	49	15	9	4	12		1
Forest species	5	1	5	5	6	4	
Introduced weeds	10	15	17	16	11	4	2

This tabulation emphasizes the fact that the sand floras connect with those of the prairie, forest, and swamp, and that the character of the three latter largely determines the character of the first.

In the plant list, the following symbols are used:

The Roman numerals at the head of the columns designate localities as follows:

[4] J. D. Whitney. American Naturalist, vol. X, pp. 577-588 and 656-667; 1876. Memoirs of the Museum of Comparative Zoology, vol. VIII, part II, pp. 166-183; 1882.

I — The beaches of the Okoboji lakes and Spirit lake.
II — Sandy shores and bars of the Iowa river below Iowa City.
III — Sandy shores and bars of the Cedar and Mississippi rivers in Muscatine county.
IV — The dunes of Muscatine county near the Cedar and Mississippi rivers.
V — The dunes of Harrison county west of Missouri Valley.
VI — The sandy and gravelly ridges along the border of the Iowan and Illinoian drifts, and elsewhere.
VII — The talus sands at the bases of St. Peter sandstone ledges in northeastern Iowa.

The species which are present are indicated in each column by the plus signs. The letters following some of the names have the following significance:

a — Species restricted to sands and gravels.
u — Species usually found in sand, sometimes on prairies.
w — Species of moist grounds or sand, or marsh species.
f — Species belonging in the forest, or at least forest borders.
i — Introduced weeds.
o — Plants of open places and often occurring on prairies.

The unmarked species belong to the prairies.

In all cases only pure sand or gravel areas without appreciable humus were considered in these studies.

		I	II	III	IV	V	VI	VII
Subkingdom III PTERIDOPHYTA								
Family								
Equisetum arvense L.	o		+	+	+		+	
Equisetum hyemale L.	o		+		+	+		
Equisetum hyemale intermedium Eat.	o				+			
Equisetum hyemale robustum (ABr.) Eat.	w	+	+					
Equisetum lævigatum A. Br.				+	+	+		
Subkingdom IV SPERMATOPHYTA								
Subclass MONOCOTYLEDONEÆ								
Family *Typhaceæ*								
Typha latifolia L.	w					+		
Family *Alismaceæ*								
Echinodorus cordifolius (L.) Gr.	w					+		
Family *Gramineæ*								
Andropogon furcatus Muhl.		+	+		+	+	+	
Andropogon scoparius Michx.		+	+		+	+	+	
Sorghastrum nutans (L.) Nash				+	+			
Digitaria humifusa Pers.	i					+		

		I	II	III	IV	V	VI	VII
Digitaria sanguinalis (L.) Scop.	i		+		+	+		
Paspalum ciliatifolium Michx.	u			+	+	+		
Panicum capillare L.	o	+	+			+		
Panicum huachuchæ silvicola H. & C.						+	+	
Panicum Scribnerianum Nash		+	+		+	+	+	
Panicum virgatum L.		+	+		+	+	+	
Echinochloa crus-galli (L.) Beauv.	i			+				
Setaria viridis (L.) Beauv.	i			+	+	+		
Cenchrus carolinianus Walt.	u	+	+	+	+	+		
Stipa spartea Trin.		+		+	+			
Aristida basiramea Engelm.				+		+		+
Aristida gracilis Ell.	u			+		+		
Muhlenbergia mexicana (L.) Trin.	o	+						
Muhlenbergia racemosa (Michx.) BSP.	o	+				+		+
Alopecurus geniculatus L.	w			+				
Sporobolus brevifolius (Nutt.) Scrib.	o						+	+
Sporobolus cryptandrus (Torr.) A.Gr.	a	+	+	+	+			
Sporobolus heterolepis Gray						+		
Sporobolus neglectus Nash	u			+	+			
Agrostis alba vulgaris (With.) Thurb.					+			
Sphenopholis obtusata (Michx.) Scrib.					+			
Kœleria cristata (L.) Pers.		+	+	+	+			
Spartina Michauxiana Hitch.	w	+	+					
Bouteloua curtipendula (Michx.) Torr.				+	+			
Bouteloua hirsuta Lag.				+	+			+
Bouteloua oligostachya (Nutt.) Torr.		+						
Tridens flavus (L.) Hitch.	u			+				
Triplasis purpurea (Walt.) Chap.	a				+			
Eragrostis Frankii (T.M.&L.) Steud.	w		+					
Eragrostis hypnoides (Lam.) B.S.P.	w		+					
Eragrostis megastachya (Koel.) Link	i		+			+		
Eragrostis pectinacea spectabilis Gray	u		+	+	+			
Eragrostis pilosa (L.) Beauv.	o		+					
Eragrostis trichodes (Nutt.) Nash	u			+				
Poa compressa L.	i	+			+		+	
Poa pratensis L.	i	+	+	+	+			+
Poa triflora Gilib.	w	+						
Festuca octoflora Walt.		+	+	+	+			
Agropyron Smithii Ryd.		+	+		+			
Agropyron tenerum Vasey		+						
Hordeum jubatum L.		+	+	+	+			
Hordeum pusillum Nutt.				+				
Elymus canadensis L.		+	+	+	+	+	+	
Elymus virginicus L.	o	+						
Family *Cyperaceæ*								
Cyperus acuminatus T. & H.	w					+		

		I	II	III	IV	V	VI	VII
Cyperus aristatus Rottb.	w	+		+				
Cyperus diandrus Torr.	w	+						
Cyperus erythrorhizos Muhl.	w	+						
Cyperus ferax Rich.	w	+	+					
Cyperus filiculmis Vahl.	a		+	+	+			
Cyperus rivularis Kunth	w	+						
Cyperus Schweinitzii Torr.	a	+	+	+	+	+		
Cyperus strigosus L.	w	+						
Cyperus strigosus compositus Britt.	w	+						
Eleocharis acicularis (L.) R. & S.	w	+						
Eleocharis palustris (L.) R. & S.	w	+						
Stenophyllus capillaris (L.) Britt.	i	+		+				
Scirpus americanus Pers.	w					+		
Scirpus validus Vahl.	w					+		
Hemicarpha micrantha (Vahl.) Britt.	w		+					
Carex cephalophora Muhl.	a		+	+	+			
Carex comosa Boott	w	+						
Carex cristata Schw.	w			+				
Carex festucacea Schk.		+	+	+	+			
Carex gravida laxifolia Bail.	w			+				
Carex hystericina Muhl.	w	+						
Carex pennsylvanica Lam.			+		+		+	
Carex scoparia Schk.	w			+				
Carex stenophylla Wahl.		+						
Carex sychnocephala Carey	w	+						
Carex tetanica Meadii (Dew.) Bail.		+						
Carex vulpinoidea Michx.	w	+						
Family *Commelinaceæ*								
Tradescantia bracteata Small				+				
Tradescantia reflexa Raf.	o		+	+	+		+	
Commelina virginica L.	a				+			
Family *Juncaceæ*								
Juncus nodosus L.	w	+						
Juncus tenuis Willd.	o		+	+	+			
Juncus Torreyi Cov.	w	+						
Family *Liliaceæ*								
Allium stellatum Ker.		+						
Smilacina stellata (L.) Desf.				+			+	
Family *Amaryllidaceæ*								
Hypoxis hirsuta (L.) Cov.							+	
Family *Iridaceæ*								
Iris versicolor L.	w	+						
Sisyrinchium campestre Bick.					+		+	
Family *Orchidaceæ*								
Spiranthes cernua (L.) Rich.	w					+		

		I	II	III	IV	V	VI	VII
Subclass DICOTYLEDONEÆ								
Salix cordata Muhl.	w					+		
Family *Salicaceæ*								
Salix amygdaloides Anders.	w					+		
Salix humilis Marsh.			+	+	+	+	+	
Salix longifolia Muhl.	w	+	+		+	+		
Salix missouriensis Bebb	w					+		
Family *Urticaceæ*								
Cannabis sativa L.	i					+		
Urtica gracilis Ait.	w	+	+					
Family *Santalaceæ*								
Comandra umbellata (L.) Nutt.		+			+		+	
Comandra umbellata Richardsoniana (Fern.)		+						
Family *Polygonaceæ*								
Rumex acetosella L.	i		+	+	+		+	
Rumex altissimus Wood				+				
Rumex brittanica L.	w	+						
Rumex crispus L.	i		+		+			
Rumex persicaroides L.	w	+						
Polygonum acre H. B. K.	w	+						
Polygonum convolvulus L.	i	+	+		+			+
Polygonum lapathifolium L.	w	+						
Polygonum pennsylvanicum L.	w		+			+		+
Polygonum ramosissimum Michx.		+	+	+	+			
Polygonum tenue Michx.	a				+			+
Family *Chenopodiaceæ*								
Cycloloma atriplicifolia (Spr.) Coult.	u			+	+			
Chenopodium album L.	i		+	+	+	+		
Chenopodium Boscianum Moq.	f	+						
Chenopodium botrys L.	i				+			
Chenopodium leptophyllum Nutt.		+	+	+	+			
Salsola kali tenuifolia G.F.W. Mey.	i	+	+	+	+	+		
Family *Amaranthaceæ*								
Amaranthus blitoides Wats.						+		
Amaranthus retroflexus L.	i	+	+					
Frœlichia floridana (Nutt.) Moq.	a			+	+			
Family *Nyctaginaceæ*								
Oxybaphus nyctagineus (Michx.) Sweet		+	+		+			
Family *Aizoaceæ*								
Mollugo verticillata L.	a		+	+	+			
Family *Caryophyllaceæ*								
Cerastium viscosum L.	i				+			
Silene antirrhina L.		+	+	+	+			
Silene noctiflora L.	i	+						
Silene stellata (L.) Ait. f.		+	+	+	+			

		I	II	III	IV	V	VI	VII
Saponaria officinalis L.	i			+				
Family *Ranunculaceæ*								
Ranunculus abortivus L.	f					+	+	
Ranunculus cymbalaria Pursh.	w	+						
Ranunculus fascicularis Muhl.					+		+	
Ranunculus pennsylvanicus L. f.	w	+						
Ranunculus sceleratus L.	w	+						
Thalictrum dasycarpum F. & L.			+	+				
Anemonella thalictroides (L.) Spach.	f						+	
Anemone canadensis L.					+			
Anemone caroliniana Walt.				+	+			
Anemone cyclindrica Gray		+	+		+		+	
Anemone patens Wolfgangiana (Bess.) Koch		+						
Clematis Pitcheri T. & G.			+	+	+			
Aquilegia canadensis L.	f	+						
Delphinium Penardii Huth.				+	+			
Family *Fumariaceæ*								
Corydalis aurea occidentalis Eng.	u			+				
Corydalis curvisiliqua Eng.	a			+				
Corydalis micrantha (Eng.) Gray	a	+		+				
Family *Cruciferæ*								
Draba caroliniana Walt.	u		+	+	+			
Lepidium apetalum Willd.		+	+	+	+		+	
Brassica arvensis (L.) Ktze.	i			+				
Brassica nigra (L.) Koch.	i			+				
Sisymbrium canescens Nutt.					+	+		
Sisymbrium canescens brachycarpon (Rich.) Wats.					+	+		
Erysimum cheiranthoides L.	o	+						
Arabis hirsuta (L.) Scop.	f	+						
Family *Capparidaceæ*								
Polanisia graveolens Raf.	a	+	+	+	+			
Polanisia trachysperma T. & G.	a	+		+				
Cristatella Jamesii T. & G.	a				+			
Family *Saxifragaceæ*								
Heuchera hispida Pursh			+	+	+		+	
Ribes gracile Michx.	f				+			
Family *Rosaceæ*								
Spiræa salicifolia L.	w		+					
Fragaria virginiana Duches.		+	+	+	+	+	+	
Potentilla arguta Pursh		+	+		+			
Potentilla canadenais L.			+	+			+	
Potentilla monspeliensis L.		+	+	+	+			
Potentilla Nicollettii (Wats.) Sheld.	w u	+						
Potentilla paradoxa Nutt.	u	+				+		

		I	II	III	IV	V	VI	VII
Potentilla rivularis pentandra (Eng.) Wats.	u			+				
Rubus occidentalis L.	f					+	+	
Rosa humilis Marsh.				+	+	+		
Rosa pratincola Greene		+	+	+	+	+		
Rosa Woodsii Lindl.				+				
Prunus americana Marsh.	f				+			
Prunus virginiana L.	f			+				
Family *Leguminosæ*								
Desmanthus illinoensis (Michx.) MacM.	u	+		+		+		
Cassia chamæcrista L.	o		+	+	+	+		
Baptisia bracteata (Muhl.) Ell.					+			
Baptisia leucantha T. & G.				+				
Crotalaria sagittalis L.	u				+	+		
Trifolium repens L.	i	+	+			+		
Trifolium stoloniferum Muhl.				+	+			
Melilotus alba Desv.	i	+	+		+	+		
Melilotus officinalis (L.) Lam.	i	+		+				
Psoralea esculenta Pursh		+						
Amorpha canescens Pursh			+		+	+	+	+
Amorpha fruticosa L.	w	+						
Dalea enneandra Nutt.	u					+		
Petalostemum candidum Michx.		+	+		+			
Petalostemum purpureum (Vent.) Ryd.		+	+		+	+		
Tephrosia virginiana (L.) Pers.	a			+	+		+	
Astragalus canadensis L.		+	+			+		
Astragalus caryocarpus Ker.		+						
Astragalus distortus T. & G.	a				+			
Desmodium canadense (L.) DC.		+	+	+	+	+		
Desmodium canescens (L.) DC.	u					+		
Desmodium Dillenii Darl.	f					+		
Desmodium illinoense Gray		+	+		+			
Desmodium paniculatum pubens T.&G.	f					+		
Lespedeza capitata Michx.		+	+	+	+	+	+	+
Lespedeza leptostachya Engelm.		+						
Vicia americana Muhl.		+						
Vicia villosa Roth	i			+				
Lathyrus palustris L.	w	+		+				
Lathyrus venosus Muhl.		+						
Strophostyles helvolus (L.) Britt.	a	+	+	+	+	+		
Strophostyles pauciflorus (Benth.) Wats.	u	+	+		+	+		
Family *Linaceæ*								
Linum sulcatum Rid.		+			+	+		+
Family *Oxalidaceæ*								
Oxalis filipes Small		+						
Oxalis stricta L.		+			+			+

		I	II	III	IV	V	VI	VII
Oxalis violacea L.			+		+		+	
Family *Geraniaceæ*								
Geranium carolinianum L.	a		+		+			
Family *Zygophyllaceæ*								
Tribulus terrestris L.	i				+			
Family *Rutaceæ*								
Zanthoxylum americanum Mill.	f			+		+		
Ptelea trifoliata L.	f			+	+			
Family *Polygalaceæ*								
Polygala incarnata L.					+			
Polygala sanguinea L.	u				+			
Polygala verticillata L.					+		+	
Family *Euphorbiaceæ*								
Croton capitatus Michx.	a			+	+			
Croton glandulosus septentrionalis (Muel.) Arg.	a			+				
Euphorbia corollata L.			+	+	+		+	
Euphorbia dentata Michx.	a					+		
Euphorbia glyptosperma Eng.	a	+						
Euphorbia maculata L.				+	+			
Euphorbia polygonifolia L.	a				+			
Euphorbia Preslii Guss.		+	+	+	+	+		
Euphorbia serpens H. B. K.						+		
Euphorbia serpyllifolia Pers.		+	+	+	+			
Family *Anacardiaceæ*								
Rhus canadensis trilobata (Nutt.)Gray	a			+	+			
Rhus glabra L.		+		+	+			
Rhus toxicodendron L.		+	+	+	+	+		
Family *Balsaminaceæ*								
Impatiens biflora Walt.	w	+						
Family *Rhamnaceæ*								
Ceanothus americanus L.			+	+	+			
Family *Vitaceæ*								
Vitis vulpina L.	f	+	+	+	+	+		
Family *Malvaceæ*								
Callirhoe triangulata (Leav.) Gray	o			+	+			
Family *Hypericaceæ*								
Hypericum cistifolium Lam.			+	+	+			
Family *Cistaceæ*								
Helianthemum canadense (L.) Michx.					+			
Helianthemum majus BSP.			+	+	+		+	
Lechea stricta Legg.	f				+			
Lechea tenuifolia Michx.	o				+		+	
Family *Violaceæ*								
Viola cucullata Ait.		+	+			+		
Viola fimbriatula Sm.				+	+			

		I	II	III	IV	V	VI	VII
Viola papilionacea Pursh						+	+	
Viola pedata L.	a		+		+		+	
Viola pedatifida G. Don.		+	+					
Family *Cactaceæ*								
Opuntia Rafinesquii Eng.	a			+	+			
Family *Lythraceæ*								
Ammania coccinea Rottb.	w					+		
Family *Onagraceæ*								
Œnothera biennis L.		+	+		+	+		
Œnothera fruticosa L.				+				
Œnothera muricata L.	u	+		+	+			
Œnothera rhombipetala Nutt.	a		+		+			
Œnothera serrulata Nutt.		+						
Family *Umbelliferæ*								
Eryngium yuccifolium Michx.			+	+	+		+	
Sium cicutæfolium Schranck.	w	+						
Zizia aurea (L.) Koch		+		+				
Pastinaca sativa L.	i			+				
Family *Cornaceæ*								
Cornus amomum Mill.	w	+						
Cornus stolonifera Michx.	w	+						
Family *Primulaceæ*								
Androsace occidentalis Pursh	a		+	+	+			
Family *Apocynaceæ*								
Apocynum cannabinum L.			+		+			
Apocynum cannabinum pubescens (R. Br.) DC.					+			
Family *Asclepiadaceæ*								
Asclepias amplexicaulis Sm.	a		+	+				+
Asclepias incarnata L.	w	+		+				
Asclepias syriaca L.		+	+		+			
Asclepias tuberosa L.		+	+		+			
Asclepias verticillata L.		+	+		+			
Acerates viridiflora Ell.					+			
Acerates viridiflora lanceolata (Ives) Gray			+		+			
Family *Convolvulaceæ*								
Ipomœa hederacea Jacq.	i			+				
Convolvulus sepium L.		+	+	+	+			
Cuscuta arvensis Beyr.	o			+	+			
Cuscuta cuspidata Eng.	o			+				
Family *Polemoniaceæ*								
Phlox bifida Beck	a			+				
Phlox pilosa L.					+			
Family *Hydrophyllaceæ*								
Ellisia nyctelea L.	o		+		+			

		I	II	III	IV	V	VI	VII
Family *Boraginaceæ*								
Lappula Redowskii occidentalis (Wats.) Ryd.		+	+					
Lithospermum angustifolium Michx.		+			+			
Lithospermum canescens (Michx.) Lam.		+	+		+	+	+	
Lithospermum Gmelini (Michx.) Hitch.	u		+	+	+			
Onosmodium occidentale Mack.		+		+	+			
Family *Verbenaceæ*								
Verbena angustifolia Michx.				+	+			
Verbena bracteosa Michx.			+	+	+			
Verbena hastata L.	w	+	+	+	+			
Verbena stricta Vent.		+	+	+	+	+		
Verbena stricta x angustifolia	u			+	+			
Family *Labiatæ*								
Teucrium canadense L.		+	+	+	+			
Isanthus brachiatus (L.) BSP.			+					
Scutellaria parvula Michx.		+						+
Prunella vulgaris L.	f						+	
Stachys palustris L.	w	+	+	+	+	+		
Monarda mollis L.		+	+		+			
Monarda punctata L.	a			+	+			
Hedeoma hispida Pursh		+	+		+	+		
Hedeoma pulegeoides (L.) Pers.			+				+	
Pycnanthemum flexuosum (Walt.) BSP.				+	+			
Lycopus americanus Muhl.	w	+						
Lycopus lucidus americanus Gray	w	+						
Lycopus rubellus Moench.	w	+						
Mentha arvensis canadensis (L.) Briq.	w	+						
Family *Solanaceæ*								
Solanum nigrum L.	i		+	+		+		
Physalis heterophylla Nees						+		
Physalis pruinosa L.		+	+		+			
Physalis pubescens L.		+			+			
Family *Scrophulariaceæ*								
Verbascum thapsus L.	i		+	+	+		+	
Scrophularia leporella Bick.		+	+	+	+			
Pentstemon gracilis Nutt.					+			
Pentstemon grandiflorus Nutt.	u	+			+			
Veronica virginica L.			+					
Gerardia tenuifolia Vahl.	w		+					
Synthyris Bullii (Eat.) Hell.	a				+			
Family *Acanthaceæ*								
Ruellia ciliosa Pursh.			+	+	+		+	
Family *Plantaginaceæ*								
Plantago aristata Michx.				+	+			
Plantago Rugelii Dcne.		+			+			

		I	II	III	IV	V	VI	VII
Family *Rubiaceæ*								
Houstonia minima Beck	a		+		+			
Family *Caprifoliaceæ*								
Symphoricarpos occidentalis Hook.		+						
Family *Cucurbitaceæ*								
Sicyos angulatus L.	f	+						
Family *Campanulaceæ*								
Specularia perfoliata (L.) A. DC.	o			+	+			
Family *Lobeliaceæ*								
Lobelia inflata L.	o				+		+	
Lobelia siphilitica L.	w	+						
Lobelia spicata Lam.					+			
Lobelia spicata hirtella Gray	w	+						
Family *Compositæ*								
Kuhnia eupatoroides corymbulosa T.&G.		+		+	+			
Liatris cylindracea Michx.		+			+			
Liatris punctata Hook.		+						
Liatris pycnostachya Michx.					+			
Liatris scariosa Willd.			+		+			
Solidago canadensis L.		+		+		+		
Solidago graminifolia (L.) Salis.		+		+	+			
Solidago missouriensis Nutt.			+	+	+			
Solidago nemoralis Ait.					+		+	+
Solidago rigida L.		+	+	+	+		+	
Solidago serotina Ait.					+	+		
Solidago speciosa angustata T. & G.			+		+			+
Aster linariifolius L.	a			+	+			
Aster multiflorus exiguus Fern.		+	+	+	+			
Aster novæangliæ L.		+			+			
Aster oblongifolius Nutt.				+	+			
Aster oblongifolius rigidulus Gray				+	+			
Aster ptarmicoides T. & G.					+			
Aster sericeus Vent.		+	+		+		+	+
Erigeron canadensis L.		+	+	+	+	+	+	+
Erigeron divaricatus Michx.					+			
Erigeron philadelphicus L.	w	+						
Erigeron ramosus (Walt.) BSP.		+	+	+	+	+		
Antennaria neodioica Greene					+		+	
Antennaria plantaginifolia (L.) Rich.	o				+		+	
Gnaphalium polycephalum Michx.				+	+			
Silphium integrifolium Michx.			+	+	+			
Silphium laciniatum L.				+	+			
Silphium perfoliatum L.	w	+						
Parthenium integrifolium L.				+				
Iva xanthiifolia Nutt.		+						
Ambrosia artemisiifolia L.		+	+		+		+	+

		I	II	III	IV	V	VI	VII
Ambrosia psilostachya DC.		+	+		+	+		
Ambrosia trifida L.	w	+	+					
Ambrosia trifida integrifolia (Muhl.) T. & G.		+	+		+			
Xanthium commune Britt.	o	+	+			+		
Xanthium speciosum Karn.	o	+						
Heliopsis scabra Dunal.		+	+	+				
Rudbeckia hirta L.			+	+	+		+	
Rudbeckia subtomentosa Pursh					+			
Bidens vulgata puberula (Wieg.) Grn.	w	+						
Brauneria pallida Nutt.			+	+	+			
Lepachys pinnata (Vent.) T. & G.		+	+	+	+			
Helianthus annuus L.				+		+		
Helianthus grosseserratus Mart.		+	+	+	+			
Helianthus occidentalis Rid.			+		+			
Helianthus petiolaris Nutt.	u			+				
Helianthus scaberrimus Ell.		+	+	+	+			
Helianthus tuberosus L.				+				
Coreopsis palmata Nutt.			+	+	+			
Helenium autumnale L.	w	+						
Dyssodia papposa (Vent.) Hitch.			+		+			
Achillea millefolium L.			+		+		+	
Chrysanthemum leucanthemum L.	i			+				
Artemisia caudata Michx.	a	+	+		+	+	+	
Artemisia dracunculoides Pursh.		+			+			
Artemisia ludoviciana Nutt.		+	+		+			
Artemisia serrata Nutt.		+						
Erechtites hieraciifolia (L.) Raf.	f			+				
Cacalia tuberosa Nutt.					+			
Senecio balsamitæ Muhl.	w	+	+					
Senecio integerrimus Nutt.		+						
Senecio plattensis Nutt.					+			
Cirsium altissimum (L.) Spr.				+	+			
Circium canescens Nutt.		+						
Cirsium Hillii (Canb.) Fern.				+	+			
Cirsium iowensis (Pam.) Fern.		+				+		
Krigia amplexicaulis Nutt.					+		+	
Taraxacum officinale Web.	i		+		+	+	+	
Lactuca canadensis L.		+		+	+	+		
Lactuca ludoviciana (Nutt.) Ridd.		+	+	+	+			
Lactuca pulchella (Pursh.) DC.		+		+				
Lactuca sagittifolia Ell.		+						
Lactuca scariola L.	i		+		+			
Lygodesmia rostrata Gray	a					+		
Agoseris cuspidata (Pursh) Steud.		+						

EXPLANATION OF PLATES

Plate I—Beach and bars.

Fig. 1—Sand beach on the south side of Gull Point on West Okoboji lake. The ridge to the left was formed by ice during the preceding winter. August, 1916.

Fig. 2—Sand and mud bar of the Missouri river soon after its formation by a flood. Harrison county, Iowa.

Fig. 3—The same bar a year later. Covered largely with young *Salix longifolia.*

Plate II—Sand dunes.

Fig. 1—A new dune near the Missouri river. West of Missouri Valley, Iowa.

Fig. 2—A somewhat older dune among the cottonwoods, in the same locality.

Fig. 3—An old dune, now covered with *Salix missouriensis* and various prairie and sand species, in the same locality. The dunes and sand flats in the background are covered with a still older cottonwood forest. The U. S. survey of 1853 shows that this part was occupied by the Missouri river at that time.

Plate III—Harrison county sand areas.

Fig. 1—A part of the forest shown in the preceding figure.

Fig. 2—A dune which had been held by *Salix amygdaloides,* but is now breaking down.

Fig. 3—A cottonwood with roots exposed by the blowing away of the sand.

Plate IV—Muscatine county dunes.

Fig. 1—A bare surface at the north end of the Big Mound, with *Gleditsia triacanthos* (dwarfed) in the background.

Fig. 2—North end of Big Mound, with bare surfaces, shifting.

Fig. 3—Dune on Big Mound which has nearly covered a fence; buried posts show at right. At left is part of a newer fence.

Plate V—Muscatine county dunes.

Fig. 1—Old dune in background, with a small "blow out." The soil in the cornfield is also very sandy. *Quercus velutina* is abundant in the sandy soil in background.

Fig. 2—*Mollugo verticillata* on blown out part of dune in fig. 1.

Fig. 3—Old sandy slope on Big Mound, now covered with prairie plants.

A STUDY OF A RED-EYED VIREO'S NEST WHICH CONTAINED A COWBIRD'S EGG

BY T. C. STEPHENS

The nest of the Red-eyed Vireo (*Vireo olivacea*) upon which this study was made was found on June 21, 1916, and contained on this date two Vireo eggs and one Cowbird's egg. The nest was of the usual type, and was suspended in a very low-hanging branch of a red elm tree (*Ulmus fulva*, fig. 1). The general location was the rather heavily wooded lake shore back of Gull Point, on West Lake Okoboji, Iowa.

The position of the nest was so low as to be ideal for study, but the distance from the Laboratory militated against attempting a continuous study. It was planned, however, to make a few short studies, especially to watch the behavior of the young Cowbird. Accordingly two full days from daylight till dark, and one-half day from daylight to noon, were devoted to this work. On July 8 the study began at 4:45 a. m., and continued without intermission until 8:22 p. m. On July 9 the observations began at 5:00 a. m. and continued till 12:00 m. On July 10 in the afternoon a brief visit was made to the nest and a single feeding visit was recorded, No. 176. On July 11 observation again started at 5:05 a. m. and continued until 8:00 p. m. Observations for shorter periods were made on the 13th, 14th and 17th.

The work at the nest-side during these periods was shared by the writer and Mr. Arthur F. Smith about equally; the latter, however, taking the early morning hours. The writer here expresses his obligation to Mr. Smith for this cordial coöperation.

To distinguish the young birds they were marked with aniline dyes in alcoholic solution. On July 8 the nest contained the Cowbird and two young Vireos. One of the latter was marked with methelyn blue, and designated "Blue;" the other was left unmarked, and designated "White."

The two parents were distinguished as follows: The male was much more shy and approached the nest more cautiously, and

usually with feathers more or less erected, especially on the crown. The female, on the other hand, was very sleek and well groomed, and displayed very little fear, or scarcely even concern. We soon discovered also that the hind toe was lacking on the right foot of the female. There was also a recognizable difference in the shape of the head in the two individuals; the crown of the male being noticeably higher, i. e., above the level of the eyes, while the crown of the female was low and flat.

No blind was erected for the study of the nest. By depressing the limb slightly, and anchoring it, the nest was low enough to be observed by the person seated. A camp chair was placed beside the nest, first at a distance of four or five feet; but within an hour or so the chair was moved so close that the observer could touch the nest, and further observations were made from this position, with no attempt whatever at concealment.

While the work of the parents went along in a fairly regular manner, there may be some question as to whether their behavior was perfectly normal, or as nearly so as it might have been with the observer concealed in a blind. The parental instincts are so strong at this period that the fear instinct is, to a greater or less extent, modified. However, if there was any modification of normal behavior on this account, it probably did not in any way alter the character of the food brought to the young birds. On one occasion prior to the commencement of the study, the writer approached the nest with care and stroked the back of the female Vireo several times before she flew from the nest. It is impossible, of course, to know to what extent the bird in such a case was possessed of fear of the intruder, and to what extent the fear instinct was subdued by the ascendency of other instincts. For further work along this line there must be devised a method of gauging or standardizing a given instinct or emotion in a wild animal.

So, while birds as fearless as these Vireos seemed to be, can be studied without concealment, it is probably doubtful whether the conclusions as to some forms of action are to be regarded as more than tentative; and general conclusions can be reached only after numerous repetitions of the studies on the same species.[1]

[1] Nevertheless I may quote the following extract from my field note-book: "Feeding today (July 11) has been very slow, but still I am inclined to think it has been normal. When the birds do come there is practically no evidence of timidity, so that it does not seem likely that they are being restrained at all by fear."

Feeding

Both parents shared in this duty, though not quite equally. The number of feeding visits during the time of observation, by hour and sex is shown in Table I.

TABLE I

SHOWING THE FEEDINGS BY THE HOUR ON THREE DAYS

Hour	July 8 Female	Male	Total	July 9 Female	Male	Total	July 11 Female	Male	Total
5:00 a.m.	5	2	7	9	3	12	5	2	7
6:00 a.m.	3	1	4	5	0	5	5	3	8
7:00 a.m.	11	4	15	9	3	12	5	0	5
8:00 a.m.	8	1	9	4	1	5	5	5	10
9:00 a.m.	8	0	8	10	3	13	3	3	6
10:00 a.m.	7	3	10	9	5	14	2	4	6
11:00 a.m.	7	0	7	6	1	7	3	1	4
	49	11	60	52	16	68	28	18	46
12:00 a.m.	14	2	16				2	1	3
1:00 p.m.	9	1	10				1	1	2
2:00 p.m.	6	1	7				3	1	4
3:00 p.m.	4	0	4				5	2	7
4:00 p.m.	4	1	5				3	2	5
5:00 p.m.	3	0	3				2	1	3
6:00 p.m.	1	0	1				2	1	3
7:00 p.m.	1	0	1				2	1	3
	91	16	107	52	16	68	48	28	76
	85%	15%		76%	24%		63%	37%	

These figures show that altogether 75% of the work of feeding was done by the female, while the male did about 25%.

There is considerable work to be done in the study of the variation of the reflexes of the nestling under varying conditions. For instance, at visit No. 75 the record shows that the Cowbird was fed a Mayfly by the female parent. But the notes say also that the morsel was first offered to White who did not respond. And at visit No. 79 the female parent fed a fat green worm to the Cowbird; again the notes say that White was tried several times without a response. Now shall we conclude that the reflex failed in the case of White because the reflex mechanism was in a state of fatigue, or because the particular food did not provide the necessary stimulus?

To answer this question let us observe that at feeding visits Nos. 17, 29, 39, 45, 50, 73, 86, 111, 133, and 198 a Mayfly did evoke the swallowing reflex in White. And that on visits Nos. 100, 155, 228, 240, and 251, it was produced in White with a green worm. Probably, then, the fault was not with the stimulus.

At visit No. 73, just four minutes before visit No. 75, White had been fed a Mayfly, and had received another feeding nine minutes previous to this. It seems fair enough to conclude that the difficulty was internal; either the reflex mechanism was fatigued, or the presence of food in the stomach set up a reflex which inhibited the swallowing reflex. At visit No. 133 a Mayfly was offered to the Cowbird, but the swallowing reflex not being promptly shown, the food was given to White, as recorded.

Sometimes this insistence by the adult on a quick response of the reflexes may work to the detriment of the young, as illustrated in the following incident. At visit No. 107 the female bird brought a large green worm, a quarter of an inch in diameter and an inch and a half long — of sufficient thickness to greatly distend the gullet of the nestling. White was tried and responded but the worm entered the gullet slowly, and the mother became impatient and jerked the worm to give it a new start, or to test another young one. White, however, held on, or could not let go, and was pulled out onto the rim of the nest, from which he toppled over and fell to the ground. As this was happening the mother bird hopped over and caught hold of the green worm in White's mouth, thus saving the worm which was now promptly fed to the Cowbird. While the Cowbird had nothing to do directly with the accident to White, yet it would not have happened, probably, if the big Cowbird (at least twice the size of either Vireo) had not been present to fill up the cavity of the nest. After feeding the Cowbird the mother bird looked carefully into the nest, as if to see what had happened, but immediately flew away, apparently without further concern. White was then replaced in the nest by the observer.

Regurgitation

Although the young were a few days old at the time of observation, a very careful watch was kept for evidence of re-

gurgitative feeding. No evidence was found.[2] In all but one or two visits the food was visible in the bird's beak, though not always identified, of course. In the feeding process of this species there is not time enough for any regurgitation. There was no instance of feeding in which the bill of the old bird was not inserted and withdrawn practically instantaneously.

Some observers have noticed a thread of saliva connecting the beaks of the parent and nestling after withdrawal of the former's bill. This saliva thread was repeatedly observed at this nest, and did not in the slightest degree suggest regurgitative feeding.

At visit No. 28 the female carried two unrecognized objects (probably snails) in her beak. One was fed to Cowbird and one to Blue. After each withdrawal a thread of saliva one and a half to two inches long was drawn out. The same saliva thread was also noted at visits Nos. 33, 53, 81, etc.

TABLE II

SHOWING THE VARIETY OF FOOD, AND THE NUMBER OF FEEDINGS TO EACH NESTLING DURING THE PERIOD OF OBSERVATION

	To Blue	To White	To Cowbird	To ?	Total
"Green worms"	19	10	20	1	50
Spiders	20	14	8		42
Lepidoptera	15	12	14		41
Mayflies	11	11	18		40
Snails	7	10	8	1	26
Miscellaneous larvae	9	7	5		22
Diptera	5	4	9		18
Probably Snails	5	1	7	1	14
Miscellaneous insects	3	1	6		10
Unknown	4	1	4		9
Grasshoppers	2		3		5
Odonata	1	1	1		3
Harvestman	1				1

Food

Table II classifies and summarizes the food. No seeds or fruit appear in the list, of course. The great bulk of the insect food is such as the birds would be able to pick from the foliage of the trees and shrubs. The food table shows the relative abundance

[2] The writer has elsewhere discussed the nature of evidence for and against this kind of feeding. See Journ. Animal Behavior, VII, 4, 1917.

of different kinds of food materials; but it is a numerical table, and does not show the quantities of food in terms of bulk or weight. Results upon the latter basis must be left for a laboratory examination.

During the short time which these Vireos were under observation we did not see any regurgitation of pellets of undigested food, as has been described by Nuttal[3] and also by Herrick.[4]

One of the most interesting facts obtained in the study of these Vireos was that land snails formed a considerable portion of the nestling diet. In the food table (Table II) it is shown that the snails stand fifth in numerical abundance. If we add to this the items which were thought to be snails (without certain identification), our total would then place the snail in the third place.

Some of the snails were specifically identified. Thus twelve snails were recognized as *Succinea avara*, and all of them were delivered by the female. At visit No. 210 the male carried one specimen of *Bifidaria armifera*. At other visits the depressed shells were brought, but these were not so easily recognized. For instance, at visit No. 200 the female brought a depressed, polished shell which must have been either *Vitrea hammonis* or *Zonitoides arboreus*, since the only similarly depressed species in the region is *Pyramidula striatella* (*P. cronkhitei anthomy*), which is not polished, but ribbed.

At visit No. 9 a snail was removed by the mother from the Cowbird's mouth, and crunched in her beak so that the observers heard the sound.

Although I have not been able to make an exhaustive search of the literature, I have been unable to find any reference to the use of snails as food by the Vireos. So we cannot say whether the present instance is an idiosyncrasy or a more general habit which has hitherto been overlooked. Perhaps it indicates a greater tendency for ground feeding than has been recognized heretofore. Although Herrick[5] makes this significant remark: "The adult Vireos glean most of their animal food from the foliage and, as might be expected, are great caterpillar destroyers, but while feeding their young I frequently saw them explor-

[3] Nuttall: Popular Handbook of Birds of the Eastern United States and Canada. Revised edition, 1911. Part I, page 185.

[4] Herrick: The Home Life of Wild Birds. Revised edition, 1905. Page 106.

[5] Op. cit., page 109.

ing the grass as any Robin or Song Sparrow might do, snapping up everything which came in their path."

The most common kind of food for the nestlings was "green worms," making up about 17% of the whole. The term is, of course, very indefinite, and refers to any soft-bodied, worm-like larva which is green in color. But since probably all of these larvae were feeding on the green foliage of one kind of another, their destruction must on the whole be beneficial, economically.

Spiders constituted next to the most abundant kind of food for the nestlings. At visit No. 264 the female bird brought a spider to the nest which was of a species that I had noticed frequently in the beaks of the parent birds, as well as often in the woods. I was able to take this specimen from the beak of the parent bird and preserve it for later identification. In due time this specimen was identified by Mr. J. H. Emerton as *Epeira trivittata* Keyserling. This is a very common round web spider, whose web is stretched between the branches of the trees at all heights up to fifteen or twenty feet, and would thus be readily found by the foliage gleaning Vireos.

Shortly after visit No. 90 the male came to the nest with a small snail, and had it in the mouth of White, when I made an effort to secure the specimen for identification; my manipulation of the forceps at his beak frightened him away, carrying the specimen with him, thus thwarting my purpose. Again at visit No. 102 the female came with two shells in her beak; in order to delay the feeding so that I might have an opportunity to identify the specimens, I made a movement to attract her attention, which, however, drove her away; but not until I had positively identified both shells as *Succinea avara.*

At visit No. 267 the female brought another *Succinea avara,* and I made a determined effort to secure it with my forceps, but failed, and it was fed to White.

Cowbird Behavior

It was hoped to make the behavior of the nestling Cowbird the special feature of this study; but its early disappearance frustrated this purpose to some extent. The young Cowbird was in the nest at eight o'clock p. m. on July 9th but was missed in the afternoon of the next day.

We never knew whether an accident befell the Cowbird, or

whether it departed from the nest in the natural way. Our attention was not drawn to the old birds giving any care to it away from the nest. The following notes were recorded on the forenoon of the 8th:

"40. 9:39 a. m. Cowbird gets his feet against one rim of the nest, and with this brace pushes backward against the young Vireos."

"49. 10:24 a. m. Cowbird attempts to preen feathers, and repeatedly raises up in nest to stretch, and at same time crowds Vireo young to the wall."

These notes suggest that the Cowbird was preparing for departure, and also the manner in which the rightful owners of the nest may be evicted.

TABLE III

SHOWING THE RELATIVE NUMBER OF FEEDINGS GIVEN EACH OF THE NESTLINGS DURING CERTAIN PERIODS WHILE THE COWBIRD WAS STILL IN THE NEST. THE RECORDS FOR JULY 8 ARE FOR THE ENTIRE DAY; THOSE OF JULY 9 ARE FROM DAY-LIGHT TO NOON

	July 8	July 9	Total	Percentage
White	18	8	26	15
Blue	30	16	46	27
Cowbird	57	44	101	58
	105	68	173	

The tabulation of the feeding visits (see Table III) shows that during the day and a half of study, before the Cowbird disappeared, it received 58 per cent of all the food. While this may seem to be an excessive proportion of food, two factors may be borne in mind, viz., that the Cowbird was both older and larger, besides being a Cowbird. The data of this study show that, during the same period, Blue, the older Vireo, got 27 per cent of the food, while White, the younger, got 15 per cent. While this may be a general and simple fact, our inquiry here is simply as to whether the Cowbird got more food by virtue of being a Cowbird, or also because of other factors. Our answer is that we cannot overlook the facts of age and size; and further discussion would relate to the instincts of the adult Cowbird in selecting the nest and time for deposition of the egg, which is beyond the present purpose.

Nuttall [6] says: "The Red-eyed Vireo is one of the most favorite of all the adopted nurses of the Cowbird; and the remarkable gentleness of its disposition and watchful affection for the safety of its young, or the foundling confided to its care, amply justifies this selection of a foster parent."

The same author also says: [7] "The most usual nurse of this bird seems to be the Red-eyed Vireo, who commences sitting as soon as the Cowbird's egg is deposited." He also suggests, in effect, that the incubation period of the Cowbird is shorter than that of the Vireo (page 107). This question should be easy of determination under favorable circumstances, and is important. If the Cowbird deposits her egg in a nest before the other eggs are laid, the rightful owner is more likely to desert. If the nest already contains a clutch of eggs, then the shorter incubation period for the parasite would be a very decided advantage.

Instinct or Intelligence [8]

Coues [9] has attempted an analysis of the behavior of the rightful owners of a nest after the intrusion of a Cowbird's egg, and his evident conclusion is that they are usually conscious of the imposition, and intelligently decide to make the best of it. Or that when the parasitic egg is buried under a superstructure, it is indicative of a mental faculty analogous to human reason. Coues states that "instinct is a lower order of reason," which view may be in harmony with the present views of behaviorists, insofar that the development of instincts precedes that of the reasoning faculty; and that intelligent behavior may in some organisms control instinctive behavior, and in the higher organ-

[6] Op. cit., page 182.

[7] Ibid., page 107.

[8] In the discussion of this topic the writer is guided by the interpretation of animal behavior as recently set forth by Parmalee in "The Science of Human Behavior." According to this interpretation the simplest form of behavior is the tropism — a direct and predictable motor response of an organism to an external stimulus. Next in order is the reflex arc — similar in action to the tropism, but operating only in the specialized tissues of the nervous system. An instinct is defined as "an inherited combination of reflexes which have been integrated by the central nervous system so as to cause an external activity of the organism which usually characterizes a whole species and is usually adaptive." Intelligent action is based upon experience and depends upon associative memory. "Intelligent behavior is therefore made up of tropic, reflex, and instinctive actions which have been combined in new ways as a result of experience so as to constitute new forms of behavior." (Page 258). Intelligent action depends upon the development of the association areas in the central nervous system, by means of which experience, or past images, may be used as stimuli.

[9] Birds of the Northwest. By Elliott Coues. Washington, 1874. Pages 180-186.

isms supercede it. He says, however, that "Instinct . . . could never lead a Summer Yellow-bird up to building a two-story nest to let a Cowbird's egg addle below." And also, on the subject of a two-story nest, "It argues as intelligent a design as was ever indicated in the erection of a building by a human being. No question of inherited tendency enters here; and if it did, the issue would only be set back a step no nearer determination, for there must have been an original double nest, the result of an original idea." A different interpretation of this behavior will be offered presently, but first let us note that Coues' conception of an instinct differs very little from our own, as indicated in the following words: "Such an 'instinct' is merely force of habit, inherited or acquired — a sum of tendencies operating unknowingly and uniformly upon the same recurring circumstances, devoid of conscious design, lacking recognized prevision; totally inadequate to the requirements of the special emergency." (*Ibid.*, page 183).

There need be no denial of the fact that the imposed-upon birds often give signs of distress at the visit of the imposter Cowbird. Similar signs of distress are shown, however, by practically all birds at the approach of an enemy. If their distress could be subjected to analysis no doubt the emotions of fear and anger would be prominent components. These emotions are commonly and readily explained as instinctive.

Suppose, now, that a Cowbird egg is deposited, and is found by the rightful owners of the nest upon their return. The most difficult problem of the case is now presented. Do the imposed-upon birds recognize the egg as an object which will hatch into a young bird larger than their own, and which will be detrimental to their own offspring? Or do they simply recognize the egg as a foreign body which does not belong in their nest? Our answer to this inquiry will, doubtless, point the way to the conclusion as to instinctive or intelligent behavior in the case.

Under one set of circumstances the Cowbird may have been discovered at the nest of another bird; the latter shows signs of excitement and opposition to the presence of the Cowbird. Upon the withdrawal of the Cowbird the exciting stimulus is removed and the reactions cease. Such behavior may take place without greater necessity of assuming intelligence than in the case of the reactions of an amoeba.

To illustrate the absence of a thought process we may recall the incident related on page 28, and note the apparent unconcern which the female Red-eyed Vireo showed when its youngest nestling was jerked out of the nest and fell to the ground. Here so serious an event as the loss of a young one did not seem to set in motion any reactions, because, as I interpret it, the stimulus was unique, and could not excite any stereotyped or instinctive response. The mechanism for instituting any new response was lacking.

Under another set of circumstances the Cowbird's eggs may have been laid in the nest. There are, at least, four possible types of response to the presence of the Cowbird's egg, viz., (1) the acceptance and continuation of incubation; (2) the abandonment of the nest and egg; (3) the removal of foreign egg from the nest by the hosts (and I do not know of any specific instance of such behavior); (4) the building of a superstructure over the intruded egg.

The relative frequency of these responses has probably not been determined. Nor will I attempt to discuss the relative complexity of the several responses. The first one named is probably the most frequent one, and possibly the simplest, since it involves only the supersedure by the highly developed chain-reflexes of the breeding period of any other reflexes which might be affected by the foreign egg. But in any of the possible cases, to put the reaction in the class of intelligent behavior, we must concede a knowledge on the part of the bird of the potential consequences of the foreign egg. It seems doubtful to the writer if the evidence will justify this conclusion, and that we are compelled to seek a simpler explanation if it is possible.

Before offering an explanation of the behavior in question in terms of reflex action, it will be necessary to describe a simple experiment performed at the Vireo's nest.

On Tuesday, July 11th, shortly after noon, the writer was at the nest, and conceived the notion of placing a small piece of green paper on the edge of the nest, for the purpose of ascertaining what effect it might have on the fairly well-established routine of behavior of the parent birds.

The male Vireo came first (visit No. 226), and fed a green worm to Blue. He then picked up the green paper quickly, but dropped it to catch the excreta sac voided by Blue. It had been

the habit throughout this day for the parents to carry away the excreta. It is well known that many nest-building birds devour the excreta sacs of the young until they reach a certain age (or until a limit is fixed by some other factor), after which it is carried away and deposited. On the occasion of this experiment the male Vireo dropped the green paper to catch the excreta, which he immediately devoured, contrary to the existing habit, and then again picked up the paper and flew away.

A similar piece of green paper was again placed in the nest, and the female bird came (visit No. 227), and fed a moth to White. Almost exactly the same performance was repeated. One fact of difference being that owing, perhaps, to the earlier stage of development of White, the habit of carrying away the excreta had been more recently established.

Somewhat later a small bit of paper was rolled into a ball and deposited in the nest, where it remained unseen by the parent birds for several visits. When the female Vireo finally discovered it (visit No. 240), she swallowed the excreta sac from White, instead of carrying it away, and flew away with the paper ball.

We cannot suppose that the birds had any knowledge of the nature of the foreign body (the paper), but its presence was a sufficient stimulus, and the removal was the reaction. Some doubt may be expressed as to whether this behavior can be ranked any higher than a reflex act, or an integration of several reflexes. It was here possible for the birds to remove the foreign object. What if it had been too large or too heavy for them to move? Would they not then have been forced to one of the other alternatives, possibly to abandon the nest or build a superstructure? So that, when the host species does resort to one or other of these two responses in the case of a Cowbird's egg, is the behavior not explainable in the same terms that we have suggested in the experiment with the paper?

It would have been interesting could it have been determined in just what manner the paper ball was deposited; since the habit of removing and depositing the excreta sac becomes a more or less stereotyped process in many species. Some birds drop the excreta while in flight, others carefully deposit it on the limb of a tree, or on the ground, etc. The removal of the foreign object (the paper) was probably a reaction controlled by very much the same nervous mechanism as that which controlled the

behavior in the excreta removal. Thus, we may explain the apparently unique behavior of the birds in promptly removing the foreign bodies, such as bits of paper, as a modification of a well-developed instinct of removing the excreta from the nest; and which is adaptive, but not purposeful.

May we not also explain the behavior of birds toward a foreign egg in the same way? May we not consider the Cowbird's egg to be a foreign body, merely, to the imposed-upon parents? And it is not only unnecessary, but unwarranted to assume that the foster parents have any knowledge of the potential capacity of this egg to hatch, or to have any conscious knowledge of the past experience by which they may draw judgments? Are the facts of this behavior not sufficiently explained in terms of reflex action, as suggested above?

The capacity for intelligent action, or the actual occurrence of it in birds under other circumstances is not denied or discussed here.

During the season of 1916 Professor B. Shimek, Director of the Iowa Lakeside Laboratory, generously placed at my disposal the facilities of this institution, and I appreciate the many courtesies and kindnesses extended to me.

EXPLANATION OF PLATES

Plate VI

Fig. 1—General view of the nest site. Nest is in depressed limb of the elm tree.

Fig. 2—Nearer view of the Vireo nest.

Fig. 3—The young are removed to show how much larger the Cowbird is than the Vireo nestlings.

Plate VII

Fig. 1—The Female Vireo inspecting the young.

Fig. 2—The Female Vireo at the nest. The pencil is held almost in contact with her bill.

Fig. 3—The Male Vireo at the nest. He was a little more aggressive and would peck at the pencil.

Plate VIII

Fig. 1—The female feeding.

Fig. 2—The female often sat for several seconds beside the nest after feeding.

Fig. 3—Inspecting.

THE PENTATOMOIDEA OF THE LAKE OKOBOJI REGION

By Dayton Stoner

The present paper is based on collecting and observations made, for the most part, in the vicinity of Okoboji lakes, Dickinson county in northwestern Iowa. It is offered as a general preliminary and progress report of a more extensive treatise, now under way by the writer, dealing with the Pentatomoidea of the entire state of Iowa. The discussion which follows includes some new distributional records within the state with notes on abundance, habitats, etc., of some species of pentatomids and presents a list of these insects occurring in northwestern Iowa which may serve as a basis for future studies in this group.

Collecting of material upon which this work is based was done during the latter half of June and at intervals during July and August, 1916. As indicated by the number of nymphs found, especially during June, it seems apparent that the season averages somewhat later in northwestern Iowa than in the central and southern portions of the state. Pentatomids were not found in any numbers on typical prairie plants before the latter part of July when such plants were only beginning to flower. Most of the specimens were taken by sweeping grasses, weeds and foliage with a hand net, while others were taken by digging about the roots of vegetation growing on sandy beaches. A large share of the collecting was done in the vicinity of the Macbride Lakeside Laboratory situated on the west shore of West Okoboji lake. In addition, outlying points as far away as Sioux City were visited. Twenty-nine of the sixty species of pentatomids now recorded from Iowa are mentioned in this paper, along with one species not before recorded and it is probable that further collecting and study will reveal several others from this most interesting region.

Acknowledgment for assistance in the collecting of specimens

is due L. L. Buchanan, Wilbur Briggs, Miss Eva Hastings, my wife, and others who were present at the Lakeside Laboratory during the summer. To Professor B. Shimek the writer is indebted for the determination of the plants hereinafter mentioned.

In the arrangement and classification of species the system adopted by E. P. Van Duzee in his Check List of the Hemiptera has been followed.[1]

A brief review of the general physiographic features of some typical collecting grounds may not be out of place here. However, for a more comprehensive account of the physiographic features of the Okoboji region as a whole, the reader is referred to Professor Shimek's paper on "The Plant Geography of the Lake Okoboji Region."[2]

The vicinity of the Macbride Lakeside Laboratory offers excellent collecting grounds all within easy access. Indeed, so many ecological areas are seldom found within so circumscribed a region. Deep woods, swamps, sandy beaches, high rolling prairies with their respective types of flora — all are within one's ability to investigate and they afford excellent opportunities for the entomologist. The Laboratory itself is situated at the head of Miller's Bay on West Okoboji lake which Professor Shimek has designated "the finest body of water in Iowa." Immediately to the south of the Laboratory grounds the topography is rough and all along the margin of the lake are rather abrupt banks on which typical forest vegetation is found. These well-wooded ridges are separated at intervals by swamps and sloughs. In the wooded areas *Cosmopepla bimaculata, Apateticus cynicus* and *Euschistus tristigmus* were found in some numbers. The region to the north of the Laboratory is high, rolling prairie.

Lookout, a considerable elevation a quarter of a mile west of the Laboratory, is about 155 feet above the level of the lake. Here, xerophytic conditions prevail and pentatomids more typical of the prairie were found, the Scutellerid *Homœmus bijugis* being most abundant.

Elm Crest, about a mile southeast of the Laboratory, presents a shore line of high, wooded banks. From here there is a gradual slope away from the margin of the lake to the southeast furnish-

[1] Van Duzee, E. P. Check List of the Hemiptera of America North of Mexico, N. Y. Ent. Soc., 1916.

[2] Bulletin from the Laboratories of Natural History, State University of Iowa, Vol. VII, pp. 4-13, 1915.

ing low, swampy areas and kettleholes. Farther to the south of Elm Crest the Beck canal has been constructed through a part of the above-mentioned swamp along a wooded peninsula. Between the canal and the woods rank growths of weeds, hazel, wild grape and willow yielded such species as *Euschistus tristigmus, Thyreocoris lateralis, Thyreocoris nitiduloides, Brochymena quadripustulata,* etc. To the south of the canal are open fields of native and cultivated grasses where *Homœmus bijugis* was found in some numbers.

Gull Point, about three miles southeast of the Laboratory, presents a fine, sandy beach extending a hundred yards or more out into the lake. The sandy soil here supports such plants as Wormwood, Rush Grass, Beard Tongue and Sedge. In the sand among the roots of these plants were found the only specimens of *Æthus obliquus* taken in the region.

Hayward's Bay offered the best pentatomid collecting ground in the vicinity of the Laboratory. Here, along the east side of West Okoboji lake is another low, sandy beach with small elevations and swales just away from the margin of the lake. A few yards directly east from the head of the bay is a small, swampy area grown up in rushes and water plants which furnished nesting places for many Red-wing Blackbirds. Excellent collecting was enjoyed along the edges of this swamp on the cultivated and native grasses. Such places yielded *Podops parvulus, Thyreocoris pulicarius* and *Thyreocoris ater.* On both north and south sides of the swamp are low hills, the larger of which presents a southwest exposure and the sandy soil supports an abundance of blue grass and red clover with a few native plants. Here, *Homœmus bijugis* was very common with *Euschistus variolarius, Coenus delius, Neottiglossa undata, Cosmopepla bimaculata* and others present in some numbers. Nowhere else in the Okoboji region were so many species of pentatomids found in such great abundance as in this small area of perhaps three acres.

Of the outlying points where good collecting was had in northwestern Iowa but three will be mentioned.

At Estherville, about sixteen miles east of the Laboratory in Emmet county, collecting was done on the upland prairie which furnishes a portion of the watershed between the Missouri and Mississippi drainage systems.

Sibley, about twenty-five miles west of Okoboji lakes in Osce-

ola county, is situated on a low, flat, prairie country with characteristic flora. There are few trees except cottonwoods and willows. However, it was not on this wild, unbroken prairie that pentatomids seemed most abundant but along the margins of cultivated fields and roadsides, where semi-cultivated areas are the rule. Few of the pentatomids seemed to be attracted by the wild prairie flowers and plants, at least during July, and most were taken from the cultivated ones such as blue grass, timothy, red clover, etc.

Toward the latter part of July, part of a day was spent in collecting southeast of Sioux City in the vicinity of Sargents Bluff. Here again it was demonstrated that at this season of the year at least, few pentatomids were to be found on the hills and high prairies that had never been under cultivation. Better results were obtained in the semi-cultivated orchards and fields and along roadsides.

Family SCUTELLERIDÆ

Subfamily Tetyrinæ

Homœmus æneifrons Say. During the summer but two specimens which can with certainty be placed in this species were taken. Two other specimens collected by M. P. Somes at Rock Rapids in September, 1914, are also referable to the present species which appears to be much less common than the following. Specimens are at hand from Lake Okoboji, Estherville, and Rock Rapids.

Homœmus bijugis Uhler. One hundred and fifty-five specimens of this form were taken mostly from prairie and blue grass pastures along the edges of woods. Of this lot twenty-two are nymphs most of which were taken in June although a few half-grown ones were taken as late as August 16. Next to *Cosmopepla bimaculata* this was the most abundant species of pentatomid found in the region. The adults became more and more evident as the season advanced until in the latter half of July and during August they reached the maximum of abundance. The species is represented by specimens from Lake Okoboji, Sibley, Estherville, Emmetsburg, Granite, and Silver Lake.

Subfamily Odontotarsinæ

Eurygaster alternatus Say. This species was taken only on low swampy prairie and roadsides grown up in timothy and blue grass at Lake Okoboji, Sibley, and Emmetsburg. It is represented by four specimens two of which are nymphs taken in July.

Family CYDNIDÆ

Subfamily Thyreocorinæ

Thyreocoris ater A. and S. Several specimens of this species were taken on the weeds and grass along the margins of both Spirit and West Okoboji lakes.

Thyreocoris nitiduloides Wolff. The most common Thyreocorid of the region and commonly found along the edges of woods and on prairie hill-side pastures. Several nymphs also were taken, most of them in July. Specimens are at hand from Lake Okoboji and Granite.

Thyreocoris lateralis Fabr. But ten specimens of this species were taken during the summer and at Lake Okoboji only. All the specimens were taken in July. They are usually found on vegetation along the edges of woods in more or less moist situations.

Thyreocoris pulicarius Germ. Two specimens only of this smallest Iowa Thyreocorid were taken in this region.

Subfamily Cydninæ

Æthus obliquus Uhler. This species, first recorded from Iowa by the writer, (Ent. News, XXIII, 182, 1916) was found in considerable numbers on the sandy beaches at Gull Point. Heretofore, no nymphs had been found but in the locality just mentioned on July 4, nymphs far outnumbered living adults. In all, sixty-three specimens were taken; fifty-seven of these were nymphs, some still in the first instar others apparently ready to molt for the last time. A number of dead adults and a single live one were also taken. The specimens were collected from among the roots of the following plants all of which grow in considerable abundance on this sandy peninsula: Beard Tongue (*Penstemon grandiflorus* Nutt.), Sedge (*Cyperus schweinitzii* Torr.), Wormwood (*Artemisia caudata* Michx.) and Rush Grass (*Sporobolus cryptandrus* (Torr.) Gray). Usually not more than three or four nymphs were found under a single plant; however, in one instance, twenty-seven nymphs of different sizes were found in the sand among the roots of one small bunch of Rush Grass. Some of the nymphs collected were found near the bases of the stalks of Rush Grass, not hidden in the sand at all but under the dead fragments of leaves and stems lying on the sand. A few specimens were found down between adjacent stalks and buried to a depth of an inch or more in the sand. At Iowa City, the first locality record for Iowa, this species has been taken only from among the roots of Rush Grass and until September, 1916, no nymphs had been taken. On September 23 a single half-grown nymph was colletced at this place.

Amnestus spinifrons Say. But two specimens of this species were secured and these constitute the only ones taken in the state during the past three summers. The present specimens were taken from blue grass on the sandy knolls immediately to the south and west of the Lakeside Laboratory.

Amnestus pusillus Uhler. One specimen of this small Cydnid was taken in July at the same locality as the preceding. The only other Iowa specimens at hand are from Iowa City.

Sehirus cinctus P. B. At Lake Okoboji to the south west of Elm Crest two specimens of this species were taken in a low cleared space grown up in timothy and blue grass. Six other specimens were taken at Forest City from weeds growing along the margins of a large drainage ditch. The species has usually been found in low places near water.

Family PENTATOMIDÆ

Subfamily Graphosominæ

Podops cinctipes Say. This and the following species were always found in damp situations and were not abundant at any time. The long grass about the swamp at Hayward's Bay proved to be the best collecting ground for members of this subfamily although but a single specimen of the present species was taken.

Podops parvulus Van Duzee. This species has not before been recorded from Iowa. Seven specimens are at hand from Lake Okoboji and Estherville. The small size, short, acute humeral tooth and somewhat explanate juga will serve to differentiate this species from *P. cinctipes*. Another specimen of *P. parvulus* has been taken at Solon, Iowa, by L. L. Buchanan.

Subfamily Pentatominæ

Brochymena quadripustulata Fabr. In the Okoboji material two half grown nymphs, taken July 4, represent this species. The specimens were taken from low willows along the Beck canal.

Peribalus limbolarius Stål. Surprisingly few specimens of this usually common species of pentatomid were taken in northwestern Iowa, the summer's quota amounting to but nine individuals; three of these are nymphs taken during July and August.

Trichopepla semivittata Say. One specimen of this widely distributed species was taken at Hayward's Bay. The species appears to be nowhere common in Iowa and most of the specimens at hand have been collected in the southern portions of the state.

Mormidea lugens Fabr. Four specimens only were taken and all at Lake Okoboji. One of these is a nymph about half grown and taken July 17. The few specimens collected were all swept from blue grass on small cleared areas in the woods.

Euschistus euschistoides Voll. Five of the twelve specimens secured at Lake Okoboji, Sioux City, and Estherville are nymphs. The species was found most often in low cultivated or semicultivated areas containing more or less timothy and red clover.

Euschistus tristigmus Say. This species was one of the most abundant woodland forms found in the region, occurring commonly in or along the edges of wooded areas on wild raspberry. Forty specimens were taken three of which are half grown nymphs. Other nymphs also were seen but not retained.

Euschistus variolarius P. B. This species did not prove to be as abundant in northwestern Iowa as in most places in the state where it is perhaps the most common of any of our pentatomids. Forty-seven specimens in all were taken and fifteen of these are nymphs representing all stages of development. At Sioux City in July the present species was found more common than in other localities visited. Other localities are Lake Okoboji, Sibley, Emmetsburg, Clarion, Silver Lake, and Forest City.

Euschistus ictericus Linn. Only two specimens of this species which very closely resembles *E. variolarius* were taken in northwestern Iowa, one at Lake Okoboji the other at Sioux City. Both present the irregular, cal-

loused ruga between the humeri which are lengthened and acutely produced.

Cœnus delius Say. Adult specimens of this species were not taken earlier than July 4 and this seems to be one of the forms that averages later in reaching maturity than many of the others. In no other species except *Apateticus cynicus* was so great a percentage of nymphs taken, for, of the thirty-three specimens collected, twenty are immature, some apparently being in the second instar. The species is most common in timothy and clover fields and along simicultivated roadsides. Localities are as follows: Lake Okoboji, Estherville, Sioux City, Emmetsburg, and Clarion.

Neottiglossa undata Say. This species was not uncommon in open country on blue grass and along roadsides but it has not been found on native prairie grasses. Occasionally a specimen was found in cleared spaces in the woods. Nineteen of the eighty-two specimens secured are immature. Nymphs in first and second instars were taken in the middle of July. Specimens from Lake Okoboji, Estherville, Emmetsburg, Clarion, Sibley, and Forest City.

Neottiglossa sulcifrons Stål. The previously recorded specimens of this species which was first taken in Iowa by the writer in 1915 were collected in the southern one-fourth of the state so it was rather a surprise to discover specimens so far to the northward. In all, ten individuals were secured from Lake Okoboji, Sioux City, and Emmetsburg. At Sioux City seven of the specimens were collected in a hilly orchard thickly grown up in long blue grass and timothy. This offered much the same sort of habitat in which the species was found at Burlington in June, 1915.

Cosmopepla bimaculata Thomas. This was by far the most common species in the vicinity of the Laboratory, particularly during June and the first half of July. It was found commonly in wooded areas and along the edges of woods especially in damp situations. On June 19, this species was swept in great numbers from Black Mustard, (*Brassica nigra* Koch.) growing in a small cleared area in the woods south of the Laboratory. Over one hundred specimens were collected in a few strokes of the hand net. On June 22, the species was found in some numbers on one of the parsnips, (*Thaspium aureum* Nutt.). The localities represented are Lake Okoboji, Forest City, Sibley, Silver Lake, Estherville, and Clarion.

Acrosternum hilaris Say. This large, green pentatomid of which but six specimens were taken, was found most often in or along the edges of woods on wild grape. Although the species has been taken at several places in other parts of the state it appears to be nowhere common and in northwestern Iowa was taken only in the vicinity of the Laboratory. It is sometimes found on wild cherry.

Banasa dimidiata Say. Four specimens only of this species were collected in similar situations to the preceding. One specimen is an adult apparently but recently molted since the body integument was still very soft when taken on August 22. This appears to be a woodland form and the few specimens collected in the state have all been found under or taken on deciduous trees.

Subfamily Asopinæ

Apateticus cynicus Say. Six nymphs and one adult of this largest of the Iowa pentatomids were taken at Lake Okoboji only. The species seems to be more typical of woodlands, apparently being most common in small cleared areas in the woods or at the edges of woods. All the nymphs were taken before the middle of July. As illustrating the predaceous propensities of this species the following incident may be mentioned. On the afternoon of July 4 while out collecting, two half grown nymphs of *Apateticus cynicus* were placed in a small tin box about two inches square together with two nymphs of *Brochymena quadripustulata* of about the same size. A portion of a raspberry and also of a grape leaf was added to the box which was not opened until the afternoon of July 8 when it was found that nothing but the empty skins of the Brochymenas were left, the *Apateticus* nymphs apparently having made a meal of them.

Podisus maculiventris Say. Apparently not a common species in northwestern Iowa. But three specimens were taken at Lake Okoboji and Sibley. At other points in the state it has commonly been taken on clover and timothy.

EXPLANATION OF PLATES

Plate IX—

Fig. 1—Sandy beach south of Laboratory dock, looking south.

Fig. 2—Low area along edge of woods south of Miller's Bay Hotel.

Fig. 3—Marsh southeast of Miller's Bay Hotel with Lake in distant background and Beck canal along edge of woods.

Plate X—

Fig. 1—Beck canal in foreground with marshes, kettleholes and woods in background.

Fig. 2—Lookout, a gravelly knoll west of the Laboratory, looking east. Native prairie in foreground.

Fig. 3—Field of red clover, timothy, blue grass, and a few native prairie plants on high prairie along C. R. I. & P. R. R. tracks, Estherville.

CLEISTOGAMY IN HETERANTHERA DUBIA

By Robert B. Wylie

The submersed aquatic plants offer an interesting field for study because of their double adaptations. As land plants they developed complex vegetative bodies and achieved the flower and seed habit. Then as water plants they faced the problem of adjusting that body and their methods of reproduction to radically different conditions from those under which their dominant traits were evolved. Among these plants are found varying degrees of specialization, and doubtless many are in process of transition to the new habitat.

The more highly specialized have elaborate structures and methods for accomplishing cross pollination at the surface of the water or while still submerged at a considerable depth. Among the members of these groups there is a pronounced tendency towards dicliny and most of them are dioecious. On the other hand, the production of perfect flowers in combination with a submerged vegetative body is commonly associated with the habit of raising an inflorescence completely above the surface of the water. In these the method of pollination is still essentially that of the land plant often without special modification. These two tendencies lessen the probability of close pollination in water plants and doubtless account for the infrequent reports of cleistogamy among the submersed aquatics.

Plants having submersed vegetative parts in association with unspecialized inflorescences and perfect flowers have difficulties in cross pollination. *Heteranthera dubia* (Jacq.) MacM. belongs to this group and is without special adaptation to air, surface, or subsurface pollination.

In connection with work at the Macbride Lakeside Laboratory on West Okoboji lake in northwestern Iowa there was favorable opportunity for the study of this species which grows abundant-

ly in the waters of the locality. It was noted that the flowers were frequently close pollinated in the bud, and the writer (1) published a brief account outlining in a general way the observed facts.

Subsequent study has shown that this species in our region is regularly cleistogamous. Under certain restricted conditions the flowers may open at the surface of the water, but in all observed cases these also have pollen tubes entering the style when the flowers open. Moreover nearly all the flowers produced on plants growing under favorable conditions for vegetative growth are so deeply submersed that it is impossible for the stigmas to reach the surface. Yet under all circumstances seeds are developed abundantly through cleistogamous fertilization.

Darwin (2) argues that cases similar to this should not be included under cleistogamy. He says (Chapter VIII) that the flowers of *Ranunculus aquatilis* and *Alisma natans*, for example, "remain closely shut as long as they are submerged, and in this condition fertilize themselves. They behave in this manner, apparently as a protection to their pollen, and produce open flowers when exposed to the air; so that these cases seem rather different from those of true cleistogamous flowers, and have not been included in the list." The writer feels that the case of *Heteranthera dubia* is quite different in that the opening of the flower, when it does occur, reveals an antecedent close pollination. The species seem therefore to have practically abandoned the chasmogamic habit and should be classed as cleistogamous even though it may not have the reduced or dimorphic flowers.

Heteranthera dubia grows luxuriantly rooted at the bottom of shallow, quiet water. While it is but sparingly present on exposed shores of larger lakes it thrives in protected bays, ponds, sloughs, etc., and in such habitats often dominates considerable areas. Since these plants are limited to water of perhaps one meter in depth it is evident that they face a double danger. There is the possibility, on the one hand of becoming too deeply submerged as a result of floods, and the probability, on the other hand, of being stranded through the lowering of the water level during the drier months of the summer. Occasionally plants are found growing on mud, but these are dwarfed to a few centimeters in height whereas under optimum conditions the plant is a yard long.

The stem branches freely in sympodial fashion giving the axis a zig zag look characteristic of this mode of growth. Roots are developed freely at the nodes and if these touch the bottom anchor the plant as it grows forward in its inclined position in the water. The leaves are grasslike with sheathing bases that clasp the stem.

Vegetative propagation is easy for water plants and they spread rapidly by means of rhizomes, buds, runners, etc., or by simply detached branches of the plant that take root and resume growth. Some of them have been known to spread in remarkable way by purely vegetative means. A striking example is seen in *Elodea canadensis*, the pistillate form of which was introduced into Europe about 1836, and overran the continent, and in a short time became a veritable pest in all quieter waters. Not until a few years ago, however, when Dr. Strasburger introduced the staminate plant of this species for experimental purposes was there the possibility of seeds in this form in Europe.

The widespread tendency of the submersed Angiosperms to produce seeds despite their favorable opportunity for vegetative multiplication emphasizes the importance of fertilization or at least of seed production in higher plants. The work of Benedict (3) indicates that the conjugation of gametes inhibits senility in the race and may afford distinct advantage in addition to all the fine strategy of the seed as an organ for plant renewal and dispersal.

The sessile flowers of *Heteranthera dubia* are borne at irregular intervals along the stem and are intermixed with the vegetative leaves. Each flower is invested by a spathe which persists until the seeds are well developed. The tubular perianth, which is about two centimeters long, is divided into six segments which in the open flower are of a pleasing yellow color and suggest by their form the common name "water stargrass." The open flower shows a bilateral arrangement of the perianth-segments and this zygomorphy extends to other members of the flower. The three stamens are inserted in the perianth tube (Fig. 1) and show considerable difference in their structures and arrangement. The single abaxial stamen rises slightly above the two equal and lateral ones, and there is no stamen on the axial or inner side of the flower. The three stamens represent probably both of the original two cycles of these organs. Solms-

Laubach (4) suggests that the abaxial stamen is a member of an outer cycle while the two lateral are members of the inner cycle of stamens.

Each anther bears four microsporangia which differ in their relations in the two forms of stamens. The two lateral anthers are alike in appearance (Fig. 3), but the abaxial has its outer sporangia widely separated and its inner, which are much reduced in size, also pulled somewhat apart. In all cases the sporangia are functional and the pair in each lateral half of the anther break together in the customary fashion forming the pollen sacs. These do not dehisce, however, until the flower opens except for a slight break on each side of the anther near its upper end (Fig. 4). The pollen output is liberal, and the spores appear to be uniformly well developed. The pollen grains are ovoid and the exine is encrusted with scale-like thickenings which stain brilliantly in safranin. A few flowers were observed to contain giant pollen grains such as Rogers (5) describes in *Melilotus alba.*

The pistil is long and slender (Fig. 1) and shows also a lack of radial symmetry (Fig. 3). The lateral lobes of the slender style are enlarged and the axial face is nearly a plane (Fig. 3). The stigma bears a tuft of finger-like stigmatic hairs. The three stylar canals, which lead to the ovary below, are initially distinct and each is lined with strongly staining glandular cells. With the passage of the pollen tubes the walls between are more or less disintegrated and sometimes the stylar chambers break together while there remains a foam-like structure filling the cavity. The ovary bears 25-35 anatropous ovules attached to the three partial partitions in the ovary.

Since the maximum elongation of the flower is only two centimeters and it can open only in the air and further is not fitted to endure wave action, the whole floral mechanism seems poorly fitted to meet the requirements of the habitat. If its insertion is more than an inch below the surface of the water the flower can not open, but, as noted above, functions as a cleistogamous bud. Practically the only conditions favoring the opening of the flowers are found along the margins of quiet water where the level is lowering. Then the stems of the vigorous plants, developed while the water at that point was deeper, come to lie

horizontal and near enough to the surface to permit the opening of the flowers in the air.

Turning now to the cleistogamous pollination one finds a relation of parts and a series of events of considerable interest. As previously reported, seeds are produced abundantly by flowers at any depth below the surface. Dissection of the mature but unopen flowers showed that the pollen tubes from spores that had germinated in the anthers had already entered the stigma. Sections show that all the pollen usually germinates though one or two cases were found in which the content of but one anther had germinated at the time the material was collected. In every flower examined at the time it was opening in the air it was found that self pollination had already taken place. Such a condition makes cross pollination impossible in any event and means that the whole floral display is now meaningless, — a memory of other days.

Longitudinal sections through the flower show the relations of all parts concerned. During the development of the flower the tip of the stigma remains considerably below the upper end of the anthers (Fig. 1) though it lies in contact all the time with the inner side of these parts. As the flower matures the style elongates and the stigma is shoved up forcibly into contact with the inner side of the anthers at their upper ends (Fig. 2). In this region occurs a slight break in the wall on each side of the anther through which the stigmatic hairs come into contact with a few of the pollen grains. These openings are limited to the upper one-tenth of the anther at this stage, and may be due to downward pressure on the anther-beaks as these press against the closed sepals. The preserved material was slightly shrunken so that one could not be sure from the sections what parts might come into contact or what tensions might be set up in the unopen flower.

The uppermost pollen grains first germinate and the stimulus is gradually transmitted downward until all the spores in the given pollen sac have formed tubes. Some of these pollen tubes pass out through the openings at the upper end of the anther and enter the stylar canals. The tubes are numerous and in favorable sections look like a rope of strongly staining threads as they lie in these cavities. The anthers are firmly cemented to the stigma by these pollen tubes; the entire content of the pollen

sac may be pulled out as a single tangled mass of spores and pollen tubes, many of which probably never find their way out of the anther (Fig. 2).

Further elongation of the style throws it into a contorted and folded form as it elongates in the narrow confines of the space within the closed perianth. Despite the many pollen tubes and the favorable conditions for fertilization, many sterile ovules are found. Probably about fifty per cent of the ovules do not develop into seeds but seem to abort immediately following the fertilization stage. With many flowers to the plant, however, and an average of perhaps fifteen seeds to the flower, the total output of seeds per plant for the summer is considerable.

Discussion

Heteranthera dubia has developed a vegetative body well adapted to the submersed life as shown by its vigorous and successful growth. It has failed, however, to attain floral specilization adequate to insure cross pollination. While the reasons for this failure can not be demonstrated, it seems to the writer that they are correlated with the perfect flowers and the ease with which close pollination could be accomplished. This would suggest that cleistogamy in this form is initial and not derived, and that it has perhaps operated to inhibit floral evolution.

The writer has elsewhere outlined (5) the alternatives presented to a submersed aquatic, one or more of which have to be adopted if it is to avoid self-pollination and still reproduce by seeds. Certain of these should perhaps be mentioned at least in relation to the possible adjustments of *Heteranthera dubia*. Many of the submersed aquatics with less highly specialized flowers raise an inflorescence above the surface of the water at the time the flowers mature. The Potamogetons and Utricularias follow this plan which is essentially a continuation of the habits of the ancestral land plants and permits either perfect or monosporangiate flowers to be used in safety. *Heteranthera dubia* can not adopt this plan as its flowers are scattered and intermixed with the vegetative leaves and there is an indefinite flowering period. *Ranunculus aquatilis* with flowers similarly scattered along the axis, gets its blossoms into the air by developing a floating stem, or one that is entirely free floating, which lies horizontal so near to the surface that a slight elevation raises

the flowers up out of the water. For our species this is impossible except where subsiding water level has brought the vegetative body developed in deeper water to lie near the surface through subsidence.

The staminate flowers of *Elodea ioensis* (6) and the pistillate flowers of *Vallisneria spiralis* are brought to the surface from considerable depths through the elongation of the pedicel or individual flower stalk. This door is closed to *Heteranthera dubia* as its flowers are sessile on a usually deeply submersed stem. It can not employ the principle of detachment in any event as its flowers are perfect; the staminate flowers of *Elodea canadensis* (7) and *Vallisneria spiralis* may detach and come to the surface to pollinate the anchored pistillate flowers.

Another way to escape close pollination would be to elongate the flower itself, such as seen in the pistillate flower of *Elodea canadensis* (7) and *E. ioensis* (6). If there has been any specialization of *Heteranthera dubia* it has been along this line for the tubular perianth and elongated style operate to push the stamens and stigmas out of the water if only slightly submerged. Since this same form of flower occurs in the terrestrial species of this genus it is evidently an ancient rather than a recent specialization. The slightly longer perianth tube in this species may be correlated with the reduced illumination since approximately one-half of the light is lost at the surface of the water. The total achievement, however, is utterly inadequate to the needs for the flowers can reach the air only when attached at the most an inch below the surface.

The remaining alternative, that of subsurface pollination through the transfer of pollen grains under water, such as is employed by *Ceratophyllum demersum* is impossible for *Heteranthera dubia* as it has perfect flowers that only open at the surface. It is thus cut off from what would seem to be the most desirable method for plants of its habitat, — a type of cross pollination which allows plants to grow and set seeds at as great depth as light permits.

From the above it is seen that all the possibilities of cross pollination except that achieved through flower elongation are closed, or have not been developed at least, so that if seeds are to be set with certainty and in considerable numbers it must be through close pollination under water excepting the relatively

few flowers so situated that they can reach the air and these also seem to have acquired the habit of self-fertilization.

It does not follow that perfect flowers in the submersed aquatics necessarily end in cleistogamy. It does seem, on the contrary, as though there were a general tendency away from bisporangiate flowers, possibly to avoid self fertilization. This is evidenced by the frequent occurrence of rudiments of the suppressed parts in flowers of this habitat. In our flora examples are seen in *Elodea canadensis, E. ioensis, Vallisneria spiralis*, etc., which are now dioecious but display more or less prominent rudiments of the suppressed stamens or pistils. Ceratophyllum, Naias, Zannichellia, Zostera, Phyllospadix, Hydrocharis, Enalus, and many other of these submersed seed plants have functionally monosporangiate flowers, a large per cent of them dioecious, with frequent expression of rudiments.

Myriophyllum spicatum, though flowering slightly above the surface of the water and having a complex inflorescence shows itself to be in transition in an interesting way. The upper part of the spike is composed of staminate flowers, which, as Knupp (8) has shown, contain mere rudiments of pistils. These abortive pistils are increasingly developed in each lower whorl of the spike until near the middle of the inflorescence they are functional in association with the stamens of the perfect flowers found there. Below this region the stamens are abortive becoming smaller in each successive whorl and at the bottom of the spike are represented by mere rudiments. There is thus a reciprocal transition from either end of the spike toward the center and the monosporangiate flowers are here without doubt derived from perfect flowers like those still showing near the center of the series. With these comparisons in mind the close pollination of *Heteranthera dubia* stands in sharp contrast to the highly specialized devices favoring cross pollination found in many of the submersed aquatics. This failure to overcome the barriers to cross pollination may be due to the structure and arrangement of the flowers, as discussed above. On the other hand it would seem that the ease and certainty with which close pollination is accomplished may have operated to inhibit floral specialization.

Ritzerow (9) has called attention to the frequency with which cleistogamic flowers, either accompanied by chasmogamic

blossoms or alone, display reduced floral parts. But there is no evidence of suppressed members in this flower other than those which occur also in the terrestrial species of Heteranthera. This strengthens the view that its flowers are unspecialized as a water plant and probably have undergone little modification in the transition.

Nor do the facts support Goebel's view (10) that cleistogamy is correlated with conditions unfavorable for vegetative growth. *Heteranthera dubia* surely suffers no lack of raw materials and its light relation is no more difficult than other plants of the same habitat. Such relation as exists between its vegetative body and its habit of self pollination is due to the vigor of its growth rather than otherwise.

It seems therefore that the cleistogamy of *Heteranthera dubia* is largely accidental and is due to the perfect flowers in relation to the tardiness or failure of the flower buds to open. No doubt this habit has operated to retard floral adjustment to the aquatic habitat through its suppression of cross pollination. The effect would be the same whether the habit of cross pollination was acquired as a land plant or after it had shifted to the water. If the species is now adjusted vegetatively to its new home its homozygous reproduction may perhaps be advantageous rather than otherwise. The species suggests itself as a favorable one for experimental study in plant breeding since it grows readily and if kept submerged sets seeds freely without further attention.

EXPLANATION OF PLATES

Plate XI—

Fig. 1—Longitudinal section through an immature flower cut slightly obliquely in the adaxial-abaxial plane. The tip of the stigma lies below the upper ends of the anthers, and the style at this stage is straight.

Fig. 2—Upper portion of an older flower cut in the same general direction as in Fig. 1. The stigma has been shoved up into the upper end of the flower in contact with the tips of the anthers where the stigmatic hairs touch the pollen grains through the breaks in the stamens. Pollen tubes are passing from anther into the stylar chambers. The style is beginning to fold through its excessive elongation.

Fig. 3—Transverse section through a nearly mature flower cut at the level of the anthers. The central style is surrounded on three sides by the stamens. The inner investment consists of the perianth lobes; the outer is the spathe.

Fig. 4—General drawing showing the relations of the upper end of the style to the anthers. The abaxial stamen is shown in face view and the ruptures in its walls may be seen on either side. The lateral stamens are shown in outline only. Stigmatic hairs at end of style.

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Fig. 1

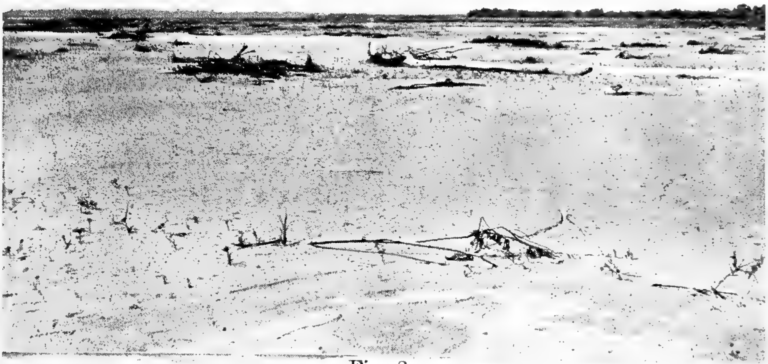

Fig. 2

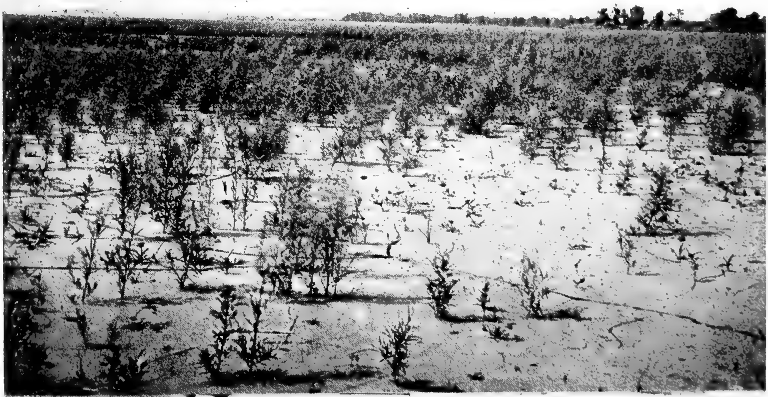

Fig. 3

PLATE I. LAKE BEACH AND RIVER BARS — Shimek

Fig. 1

Fig. 2

Fig. 3

PLATE II. SAND-DUNES, HARRISON COUNTY — Shimek

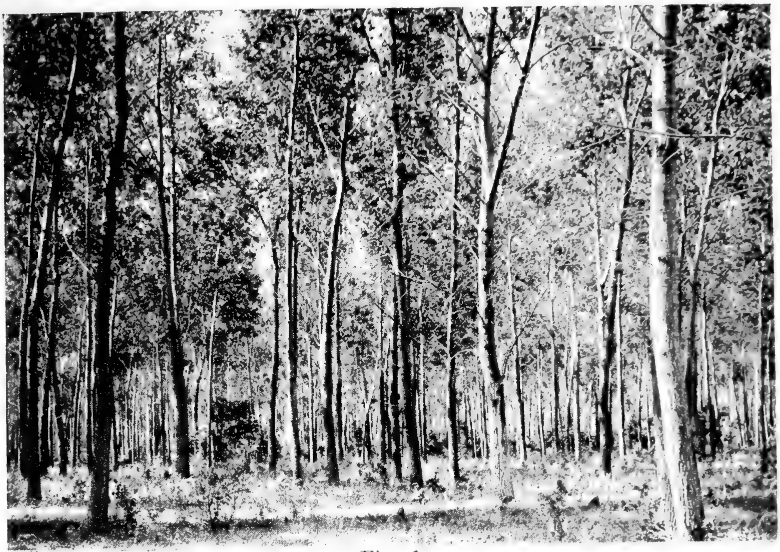

Fig. 1

Fig. 2

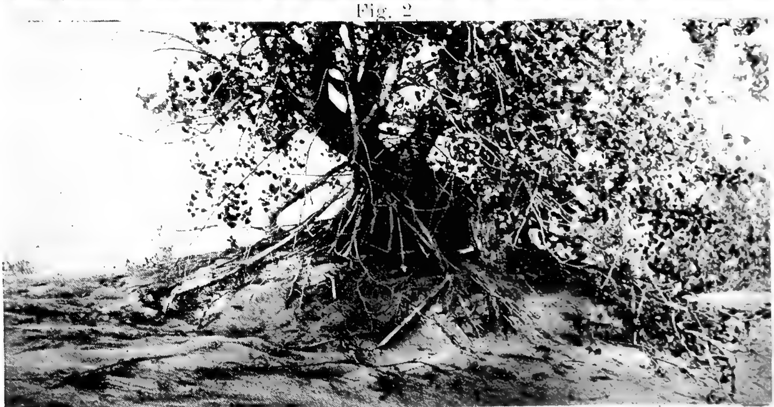

Fig. 3

PLATE III. OLDER DUNES, HARRISON COUNTY — Shimek

Fig. 1

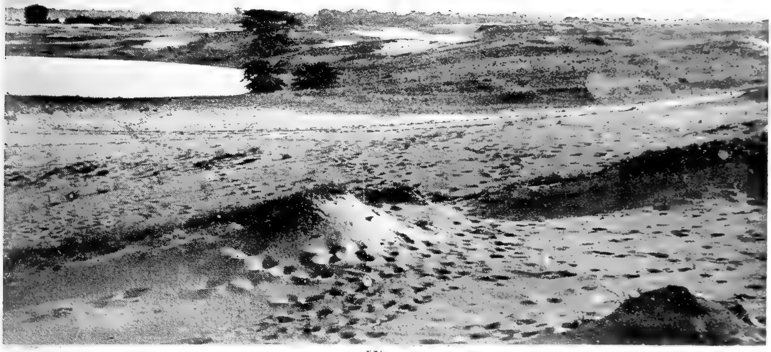

Fig. 2

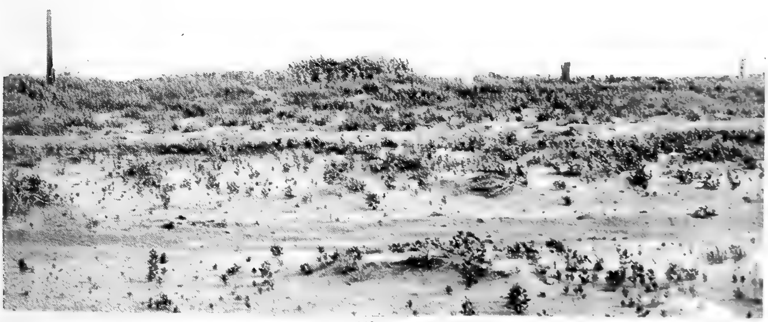

Fig. 3

PLATE IV. SHIFTING DUNES, MUSCATINE ISLAND — Shimek

Fig. 1

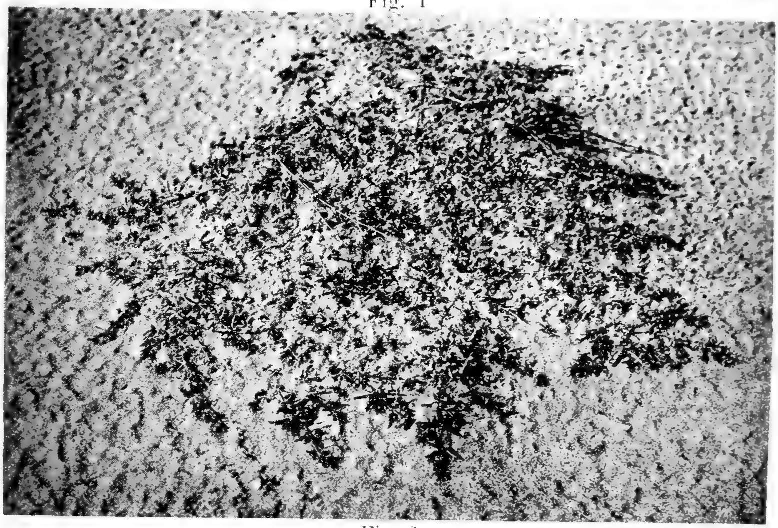

Fig. 2.

Fig. 3

PLATE V. SAND-DUNES NEAR BAYFIELD — Shimek

Fig. 1

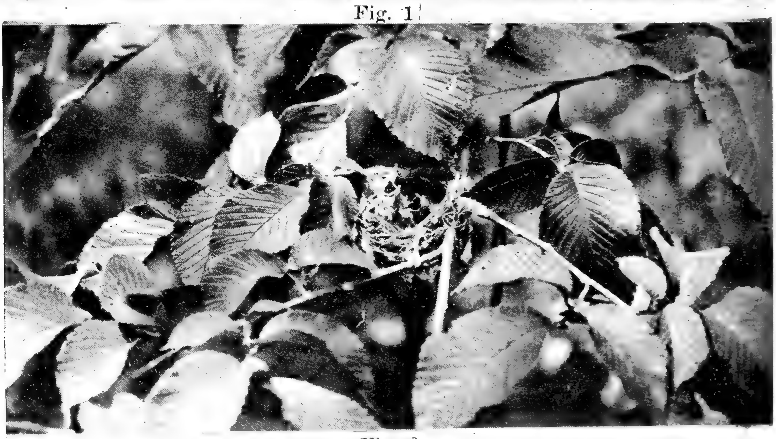

Fig. 2

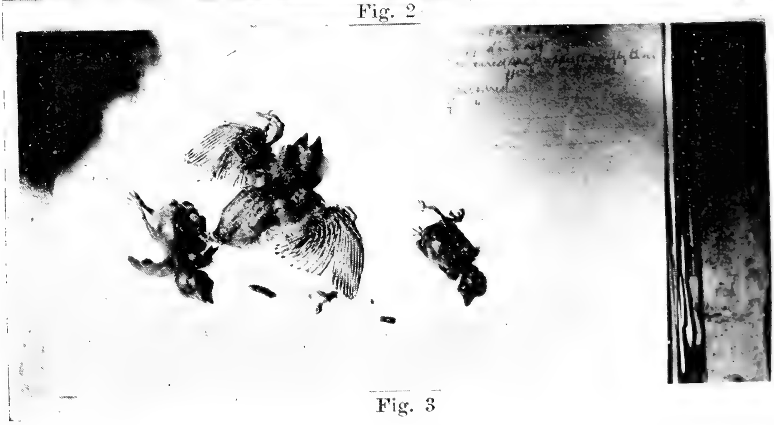

Fig. 3

PLATE VI. NEST AND YOUNG OF RED-EYED VIREO — Stephens

Fig. 1

Fig. 2

Fig. 3

Plate VII. Nest of Red-eyed Vireo — Stephens

Fig. 1

Fig. 2

Fig. 3

Plate VIII. Nest of Red-eyed Vireo — Stephens

Fig. 1.

Fig. 2.

Fig. 3.

PLATE IX. HABITATS OF OKOBOJI PENTATOMOIDEA — Stoner

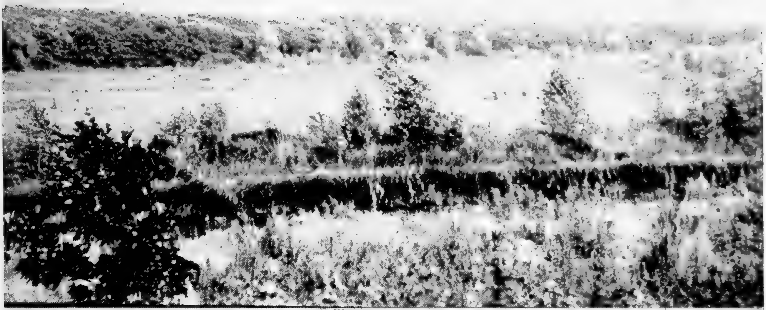

Fig. 1.

Fig. 2.

Fig. 3.

PLATE X. HABITATS OF OKOBOJI PENTATOMOIDEA — Stoner

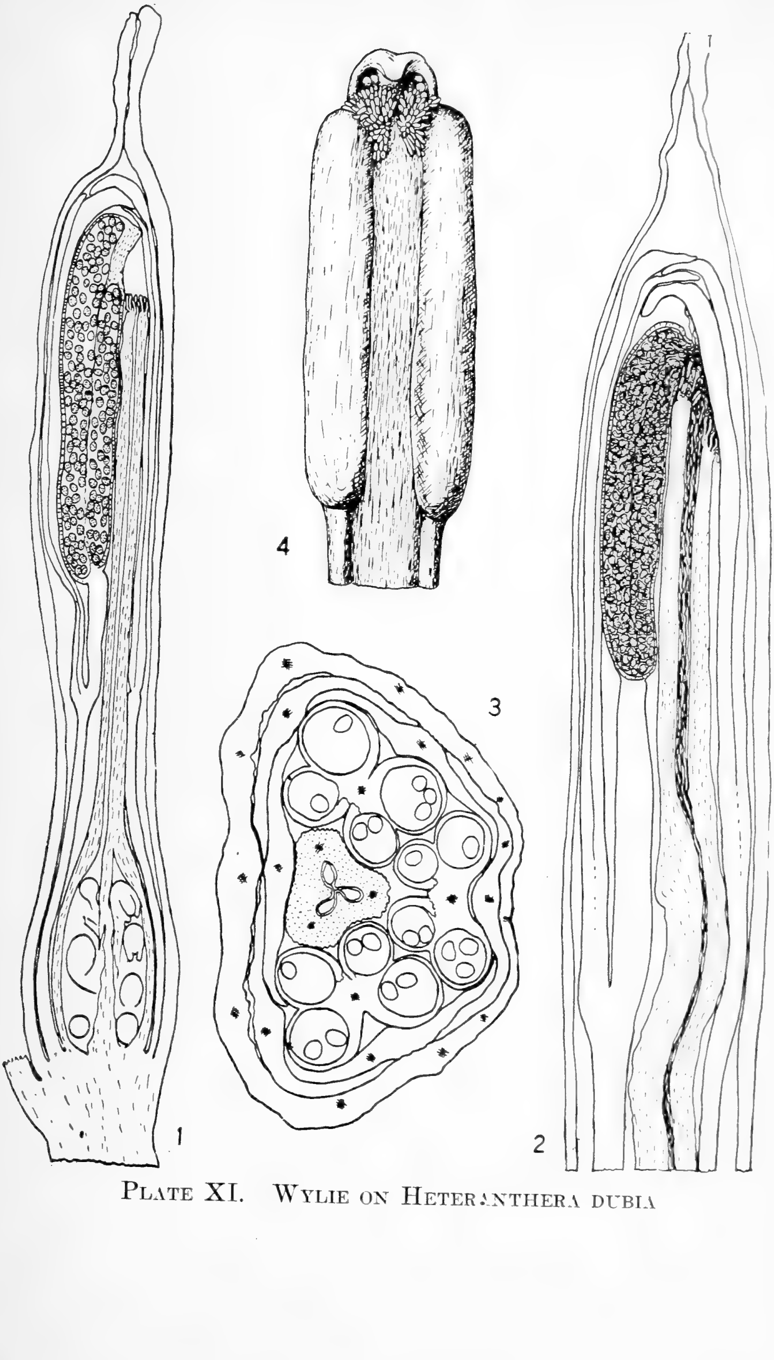

PLATE XI. WYLIE ON HETERANTHERA DUBIA

517

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UNIVERSITY OF IOWA MONOGRAPHS

BULLETIN FROM THE LABORATORIES OF NATURAL HISTORY

VOLUME VII NUMBER 5

REPORT ON THE CRINOIDEA AND ECHINOIDEA

Collected by the Bahama Expedition from the University of Iowa in 1893

by

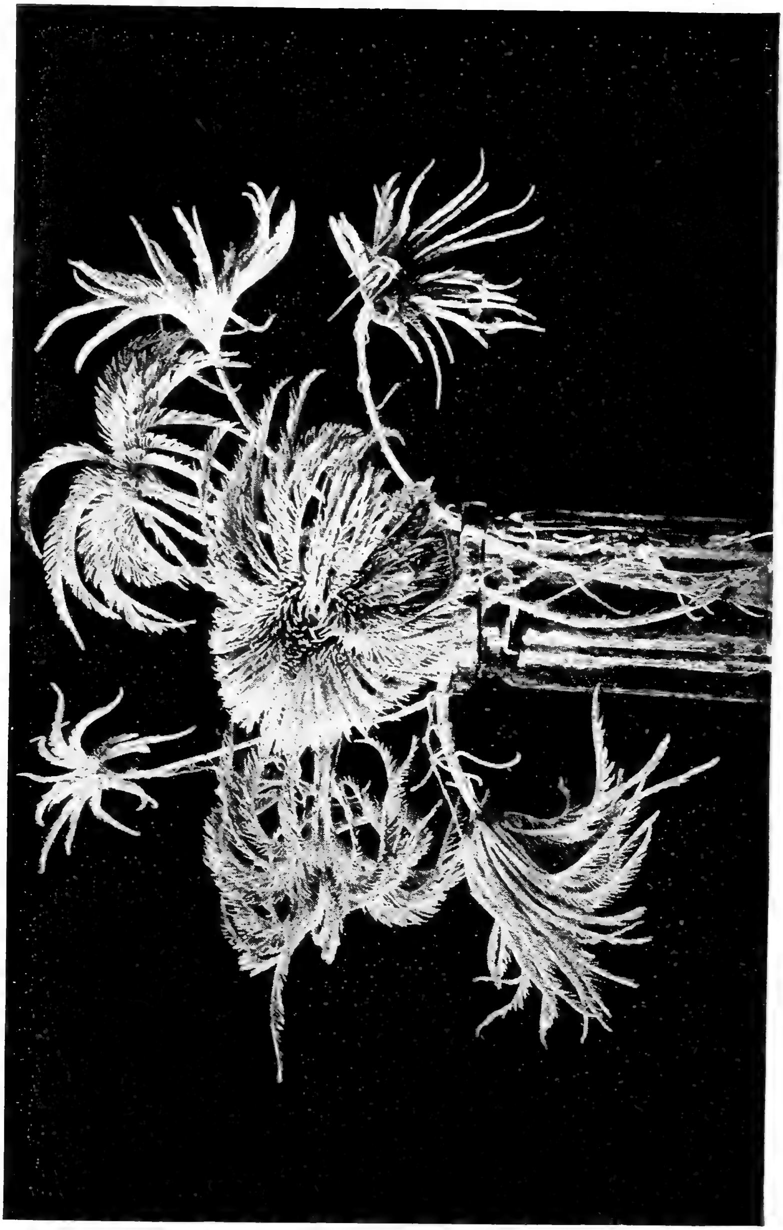
HUBERT LYMAN CLARK, PH. D.

Museum of Comparative Zoölogy, Cambridge

PUBLISHED BY THE UNIVERSITY, IOWA CITY

ISSUED MONTHLY THROUGHOUT THE YEAR. ENTERED AT THE POST OFFICE AT IOWA CITY, IOWA, AS SECOND-CLASS MATTER

PLATE I.



A Bouquet of "Sea Lilies" (from *Nat. Hist. Bull.* III., 1, 2)

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Report on the Crinoidea and Echinoidea

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By Hubert Lyman Clark, Ph. D.
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Early in March, 1916, the collections of crinoids and sea-urchins made by the University of Iowa's Bahama Expedition in 1893 were placed in my hands for study and identification. No collection of holothurians was made by the Expedition, while the sea-stars and brittle-stars have been reported on by Professor A. E. Verrill (Nat. Hist. Bull., V, 1 and VII, 1). To complete the account of the Echinodermata, therefore, it is desirable that a report be made on the collections turned over to me. While there is no close relationship between the crinoids and echinoids (indeed they represent quite different lines of evolution from a presumably Cystid stock), it is most convenient to embody my notes on the two groups in a single report. For the honor done me, in placing this interesting material in my hands, as well as for his help by correspondence, I wish to offer my sincere thanks to the leader of the Bahama Expedition of 1893, Professor C. C. Nutting.

It is to be regretted that the crinoids and echini were not studied soon after they were collected, for during the past twenty years much has been published on these groups as found in the West Indian region. There is not, therefore, any now undescribed species in the series before me though there are probably five crinoids and one sea-urchin which were new to science when taken. The chief value of the collections now lies in the large series of young echini, which throw much light on the growth stages of several little known species, and in the data provided on the distribution of the species represented. The notes on the Echinoderms taken at the various stations, published in Professor Nutting's "Narrative" of the Expedition (1895, Bull. Univ. Iowa, Lab. Nat. Hist., vol. 3, nos. 1 and 2) are not only of great general interest but are of much scientific

value, and have been of real service to me in the preparation of this report. I have quoted from them very freely but they should certainly be consulted by anyone interested in echinoderms.

CRINOIDEA

The collection of crinoids sent to me consists of 1310 specimens, representing 13 species, but unfortunately *Cocometra hagenii* makes up nine lots totalling 1247 specimens, while six of the species are represented by only one specimen each. There are 20 specimens of three species of stalked crinoids, while a fourth species is represented by a photograph of a fine example in the Iowa University Museum, identified by Dr. Charles Wachsmuth, the eminent authority on fossil crinoids. It gives me great pleasure to acknowledge the help I have received from my friend, Mr. Austin H. Clark of the United States National Museum, whose admirable work on the crinoids, has made all workers on echinoderms, his permanent debtors. Mr. Clark was good enough to look over the collection one afternoon when he was in Cambridge and he has also helped me by correspondence. He must not be held responsible however for any errors of identification which may hereafter be found or for any of the statements made herein. I have followed the arrangement of genera and species given in his "Recent Crinoids of the British Museum" (1913, Smith's Misc. Coll., *61,* no. 15) so far as possible.

I have ventured to give a key to the 14 species listed here, not because it can be of permanent value but in the hope that since it includes the more common species, it will be of a little help to collectors not acquainted with crinoids in sorting collections made in the West Indies. Of course, the key cannot be relied on to lead to correct identifications since the number of crinoids now known from the West Indies is several times fourteen, but it will at least suggest to a beginner the characters which are of general service in distinguishing genera and species of this difficult group. All lovers of echinoderms are awaiting impatiently Mr. A. H. Clark's systematic monograph, which will be to the crinoids what Mr. Agassiz's Revision has

so long been to the echini, and will make the correct identification of species practicable, if not easy. Identifications made with the following key must be verified by comparison with the original (or with later and fuller) descriptions, or they can have little value.

Key to the Crinoids included in the present report

No stalk.

Basal pinnules (at least the first pair) with a well-marked comb at tip; mouth usually excentric.

Centrodorsal flat and discoidal.

Cirri with dorsal spines on distal segments.

II Br. 2 (i. e. the first division series of each ray consists of only two segments) .... *Neocomatella alata*

II Br. 4 (3+4) (i. e. the first division series consists of four segments, the third and fourth united by syzygy).

Cirri XV-XXI, with 10-12 segments...... *Nemaster insolitus*

Cirri XXX-XL, 12-18 .... *Nemaster iowensis*

Cirri smooth without dorsal spines; only 10 arms .... *Comactinia echinoptera*

Centrodorsal conical, crowded with about 40 cirri, having 14-17 segments of which several proximal ones are very long and slender.................... *Comatonia cristata*

Basal pinnules without terminal combs; mouth central.

Cirrus segments with dorsal, transverse, serrate ridges, contracting to a single spine on the penultimate segment; cirri about XV, 20 .... *Analcidometra armata*

Cirrus segments smooth, or with a single spine, dorsally.

Cirri very long with 40-60 or more segments, of which the distal ones have conspicuous dorsal spines,.......... *Stylometra spinifera*

Cirri shorter, with 10-20 segments.

Arms more than 10; cirrus joints stout, even the proximal rarely twice as long as broad.

Cirri XIV-XV, 11-12......... *Crinometra gracilis*

Cirri XX or more, 15-20....... *Crinometra ornata*
Arms 10; cirrus joints very slender, many of the proximal 2-3 times as long as broad; cirri XXX or or more, 18-20.................. *Cocometra hagenii*

Stalk present
Cirri present on stalk
Internodes of stalk commonly with 6-9 segments...... .... *Endoxocrinus parrae*
Internodes of stalk commonly with 15-18 segments...... .... *Isocrinus asteria*
Internodes of stalk commonly with 11-14 segiments...... ....*Isocrinus decorus*
Cirri wanting ....*Democrinus rawsonii*

Neocomatella alata

Antedon alata Pourtalès, 1878, Bull. M. C. Z., *5*, p. 215.
Neocomatella alata A. H. Clark 1909. Prof. Biol. Soc. Washington, *22*, p. 177.
Actinometra echinoptera var. *alata* Hartlaub, 1912. Mem. M. C. Z., *27*, p. 444; pl. XVIII, figs. 15 and 16.

This species is represented in the collection by only two specimens. One of these has 15 arms about 50 mm. long. The other has only 13 arms, and all the cirri are lacking. Both are from St. 10 or its vicinity. Station 10. Cuba: off Havana, 200 fms.

Nemaster insolitus

A. H. Clark, 1917. Proc. Biol. Soc. Washington, *30*, p. 65.

A single specimen of Nemaster answers so well to Clark's description, that I have no doubt it represents this species. It is in only fair condition, however, and unfortunately has no locality label. The centrodorsal is 4 mm. across, flat and discoidal. There seem to have been 21 cirri but only 9 remain. These and the centrodorsal are white, while the arms, of which there were 18 (8 are broken off), are light brown, with the center of the serrate, distal margin of each brachial, darker brown; the pinnules are lighter.

Nemaster iowensis

Actinometra iowensis Springer, 1902, Amer. Geol., *30*, p. 98. 1903, Bull. Lab. Nat. Hist., Univ. Iowa, *5*, p. 217; pl. 1.
Nemaster iowensis A. H. Clark, 1910. Ann. Mag. Nat. Hist. (8), *5* p. 361.

Certainly, among the echinoderms taken by the Bahama Expedition, no species is so remarkable as this. Collected in shallow water at the Tortugas, the specimens were at once recognized by Professor Nutting as of very unusual interest, and in the "Narrative" (pp. 129-130) he speaks of them as follows: "Perhaps the greatest surprise was when we found a magnificent crinoid with a spread of about twelve inches growing in water less than three feet deep. These specimens were of a rich golden-brown color, which has not faded in alcohol, and belonged to the genus Actinometra. The mouth is even more excentric than usual in this genus and the pinnules are long and slender. The arms appear to be more brittle than in other crinoids and the ultimate ramifications are twenty-four in number. This is probably the handsomest species of free crinoid secured during the cruise, and the unexpectedness of the discovery added to its interest."

The structural peculiarities of the species have been fully discussed and figured by Springer, and it is not necessary for me to enter into them. But it may be worth while to add a few words in regard to the subsequent history of this notable comatulid. Professor Nutting says in a footnote (p. 130) that Mr. Agassiz told him he had found large comatulæ in shallow water at the Tortugas. It is greatly to be regretted that no such comatulids are in the M. C. Z. collection. It is possible they were sent to Hartlaub many years ago with most of the M. C. Z. comatulids. If so they are still missing, as that eminent German scientist never returned to the Cambridge Museum any of its collection, save a full series of *Comactinia echinoptera*. All else, he reported, as hopelessly lost!

Since the establishment of the Marine Laboratory of the Carnegie Institution at the Tortugas in 1904, Dr. Mayer has made a constant effort to rediscover *Nemaster iowensis*, but without finding a single specimen. The present writer spent the month of June, 1917, at the Tortugas and at every oppor-

tunity searched the reefs and shoals in the effort to find at least one comatulid. Dredging was also carried on continually, but all efforts were vain, for not a trace of a comatulid was found. Either this species formerly occurred and has now died out, or else its normal habitat is in that inaccessible region of the reef where it is too deep to wade and too shallow and rough to work from a boat; and from this habitat it only accidentally or under unusual conditions comes up into more shallow water.

Comactinia echinoptera

Alecto echinoptera J. Müller, 1841. Ber. Verh. Akad. Wiss. Berlin, p. 183.
Comactinia echinoptera A. H. Clark, 1909. Proc. U. S. Nat. Mus., *36*, p. 498.

Although Hartlaub devotes two full plates in his account of the "Blake" comatulids, to photographs of *echinoptera* (Mem. M. C. Z., *27* pls. XVI, XVII), he has confused so many different species under that name, that it is not safe to say which of his figures is the true *echinoptera*. One can only wait until Mr. A. H. Clark has completed his work on West Indian crinoids and has brought order out of the chaos in which Hartlaub has left the subject.

The specimens in the Iowa collection agree well with each other and with the description of Müller's type so there is no reason to doubt their identity. They were all taken on the Pentacrinus ground, off Havana, and are for the most part rather badly broken. Most of the specimens are now quite white, but a few are distinctly light brown and one is evidently somewhat purple, especially on the arm-bases. In the "Narrative" (p. 75), Professor Nutting says: "Bright yellow Comatulæ were fairly abundant and white or nearly white Comatulæ were also secured at this place" (i. e. the Pentacrinus ground). Again (p. 75), he says: "Besides the Pentacrini, a number of species of Comatulæ, including several Actinometra, served to enlarge our series of crinoids." There are 5 species of comatulids in the collection sent me, which were taken on the Pentacrinus ground, but *Comactinia echinoptera* is the only one of which more than two specimens occur. It seems likely that this is the species of Actinometra to which he refers and also

that it is the "bright yellow" comatulid which he says was "fairly abundant." The following stations are the places where the 31 specimens at hand were taken:

Station 2. Cuba: off Havana, 110 fms.
Station 4. Same as 2.
Station 5. Cuba: off Havana, 140 fms.
Station 7. Same as 5.
Station 9. Cuba: off Havana, 200 fms.
Station 10. Same as 9.
Station 11. Same as 9.
Station 13. Cuba: off Havana, 200 fms.

Comatonia cristata

Actinometra cristata Hartlaub, 1912. Mem. M. C. Z., *27*, p. 473; pl. XV, figs 10 and 11.
Comatonia cristata A. H. Clark, 1916. Jour. Washington Acad. Sci., *6*, p. 115

There are but three specimens of this comatulid in the collection and they are in only fair condition but they show the prickly crests on the lower brachials much more clearly than they appear in Hartlaub's figures. The species is so much like one of the Antedonidæ superficially that specimens lacking the extraordinary basal pinnules would be very difficult to identify, but the combs on those pinnules are certainly very characteristic.

Station 30. Florida: south of Key West, about 100 fms. 1 specimen.
Station 48. Florida: southeast of Key West, about 80 fms. 2 specimens.

Analcidometra armata

Antedon armata Pourtalès. 1869. Bull. M. C. Z., *1*, p. 356. Hartlaub, 1912. Mem. M. C. Z., *27*, p. 394; pls. VII, figs. 1-7; XIII, fig. 7.

Mr. A. H. Clark tells me that this species, so long ago described by Pourtalès, is properly a member of the genus Analcidometra, instituted by Mr. Clark in 1911 (Mem. Australian Mus., *4*, p. 779), but I cannot find that the combination has been published hitherto. The species is easily recognized

among the comatulids of the present collection by its characteristic cirri. There are two specimens before me, each with disk about 3 mm. across and arms 50 mm. long.

Station 74. Bahamas: off Little Cat Island, 3-13 fms. 2 specimens.

Stylometra spinifera

Antedon spinifera P. H. Carpenter, 1881. Bull. M. C. Z., *9*, p. 158. Hartlaub, 1912. Mem. M. C. Z., *27*, p. 358; pl. II.

Stylometra spinifera A. H. Clark, 1908. Bull. M. C. Z., *51*, p. 245.

A single fine specimen of this beautiful species is all that the present collection contains. Unfortunately the cirri are all broken but enough is left of one to reveal the characteristic features.

Station 2. Cuba: off Havana about 2½ miles, 110 fms.

Crinometra gracilis

Antedon brevipinna var. *gracilis* Hartlaub, 1912. Mem. M. C. Z., *27*, p. 328; pl. XII, fig. 3.

There are in the Iowa collection two comatulids and fragments of a third which undoubtedly belong to the genus Crinometra. In regard to the species of this genus, Mr. A. H. Clark writes me: "Crinometra is in a perfectly hopeless condition. The majority of the new names given by Hartlaub are preoccupied in the genus Antedon as understood by him." In spite of this situation, it has seemed desirable to at least place the specimens before me with reference to Hartlaub's many "varieties" of *Antedon brevipinna*. One of these specimens, although fragmentary, seems to answer well to the "variety *gracilis*" and I have therefore labelled it "*Crinometra gracilis* Hartl." The question as to whether *gracilis* in this usage is preoccupied by *Antedon gracilis* may be ignored until Hartlaub's multitudinous varieties are properly identified.

The specimen at hand has a thick, flat or slightly conical centrodosal, only a little more than 3 mm. in diameter; there are 10 cirri present and sockets of 3 or 4 more; the bare dorsal surface of the centrodorsal is occupied by numerous bluntly pointed granules or thick spinelets. The cirri have 11 or 12

segments and resemble very closely the one shown in Hartlaub's photograph (pl. XII. fig. 3). The two arms remaining are 75-80 mm. long and their ornamentation is very similar to that shown in Hartlaub's figure. There were 18 arms, with syzygies between brachials 1 and 2 and again between 3 and 4, as described by Hartlaub. The pinnules also agree well with his description. The color is uniformly white. While there seems little reason to doubt, therefore, that this specimen is identical with Hartlaub's, what its relation is to the other species of Crinometra remains to be determined.

Station 2. Cuba: off Havana about 2½ miles, 110 fms.

Crinometra ornata

Antedon brevipinna var. *ornata* Hartlaub, 1912. Mem. M. C. Z., *27*, p. 348; pls. IV, fig. 6; XII, fig 4.

The specimen and fragments of this Crinometra do not correspond in detail with Hartlaub's description and figures, but it is better to refer them to the same *name* than introduce a new name into this already badly confused group.

The individual before me has the centrodorsal so thickly covered with cirri that it is difficult to determine its size and shape. At the dorsal pole are a few high, compressed, irregular granules and ridges. The cirri are about 20 in number, with 17-20 segments, of which the penultimate bears a conspicuous opposing spine, while the 3-6 preceding have a similar but increasingly ill-defined dorsal projection near the distal margin; the distal margins, particularly of the basal segments, are flaring so that they form a conspicuous socket for the next succeeding segment; all the segments are longer than wide, except the basal three, and the fifth (or sixth) is the longest. There are 23 arms, of which two are very small; the longest exceed 100 mm. In their ornamentation, the arms are more like Hartlaub's fig. 9, pl. V, than they are like the figures he gives for *ornata*, but I am not at all clear as to how much weight slight differences of ornamentation properly carry in Crinometra. The pinnules of the specimen in hand are remarkable for the very great width of some of the basal segments. Thus P_5 is 6mm. long, and consists of 10 segments of which the third is .75-.80 mm. high and a trifle

more than 1 mm. wide, while the fourth is about as wide and is fully a millimeter high; succeeding segments are much narrower. It will be at once noted that these pinnules are utterly different from Hartlaub's fig. 6, pl. IV, but they are apparently identical with those shown in the photograph, fig. 4, pl. XII. No doubt Hartlaub has at least two distinct species confused under his "variety *ornata!*" The arm-fragments at hand agree perfectly in ornamentation and in pinnules with the whole specimen and there is no doubt of their identity.

Station 9. Cuba: off Havana, 200 fms. Arm-fragments.

Station 16. Cuba: off Havana, 200 fms. 1 good specimen.

Cocometra hagenii

Comatula (*Alecto*) *hagenii* Pourtalès, 1868. Bull. M. C. Z., *1*, p. 111.

Cocometra hagenii A. H. Clark, 1908. Proc. Biol. Soc. Washington, *21*, p. 128.

Antedon hageni Hartlaub, 1912. Mem. M. C. Z., *27*, p. 389; pl. VIII, figs. 1-12.

The vast majority of the crinoids in the Iowa collection belong to this common species. In the "Narrative" (p. 164), Professor Nutting says that "great numbers of crinoids were collected" on the Pourtalès Plateau. On one occasion, "as the bar neared the surface and the tangles themselves could be seen rising through the blue water, we noticed that a stream of brownish objects was trailing after it, as if innumerable mossy bits were floating away from the hemp strands. When the tangles came on board we found them literally covered with a mass of crinoids, all of one kind and quite small. We estimated that at least five hundred specimens came up in that haul and it was evident that hundreds or thousands had washed off during the ascent of the tangles from the sea-bottom. This was probably the greatest number of any one species obtained at a single haul during the entire cruise. The bottom must have been actually packed with them in spots." There is no doubt that the crinoid here referred to is *Cocometra hagenii.* There is little doubt that Hartlaub's figures represent more than a single species and it is difficult to determine which really illustrate *hagenii.*

The Bahama Expedition took this species at the following stations:

Station 27. Florida: south of Key West, 50-60 fms. 5 specimens.

Station 33. Florida: about 6 miles south of Sand Key Light, about 105 fms. 1 specimen.

Station 48. Florida: southwest of Key West, about 80 fms. 6 specimens.

Station 54. Florida: about 10 miles southeast of American Shoal Light, about 130 fms. 185 specimens.

Station 57. Pourtalès Plateau, 24° 18′ N. x 81° 18′ W., 200-225 fms. 365 specimens.

Station 58. Pourtalès Plateau, 24° 19′ N. x 81° 19′ W., about 200-225 fms. 275 specimens.

Station 62. Florida: off American Shoal Light, 70-80 fms. 205 specimens.

Station 64. Florida: about 8 miles southeast of American Shoal Light, about 110 fms. 95 specimens.

Locality unknown. 110 specimens.

Endoxocrinus parræ

Encrinus parrae Gervais, 1835. Dict. d'Hist. Nat., *3*, p. 49; pl. 147. fig. 1

Pentacrinus mülleri Oersted, 1856. Forh. Skand, Nartuf. p. 202. P. H. Carpenter, 1884. *Challenger* Crinoids, pt. 1, pl. XIV.

Endoxocrinus parrae A. H. Clark, 1908. Proc. Biol. Soc. Washington, *21*, p. 151.

Plates I and II

Here is another of those unfortunate cases where a long familiar name has to give away to an older and less euphonious one. This beautiful crinoid was taken a number of times on the Pentacrinus grounds off Havana but it is evidently not nearly so common there as is *Isocrinus decorus.* In the "Narrative" (pp. 73, 74), it is recorded that "when fresh, *P. mülleri* is darker colored than *P. decorus,* and is a handsomer species on account of the greater number of arms." "*Pentacrinus mülleri*......came up with the head erect and the numerous arms very greatly recurved, usually meeting below the calyx," as do the "perianth-segments" of some tiger-lilies.

Station 4. Cuba: off Havana, about 2½ miles, 110 fms. 2 specimens.

Station 5. Cuba: off Havana, about 2½ miles, 140 fms. 1 specimen.

Station 10. Cuba: off Havana, about 2½ miles, 200 fms. 1 specimen.

Station 13. Cuba. off Havana, 200 fms. 1 specimen.

Station 16. Cuba: off Havana, 200 fms. 1 specimen.

Isocrinus asteria

Isis asteria Linné, 1766. Sys. Nat. ed. 12, p. 1288.

Pentacrinus asterius P. H. Carpenter, 1884. *Challenger* Crinoids, pt. 1, p. 300; pl. XI.

Isocrinus asteria A. H. Clark, 1908. Proc. U. S. Nat. Mus., *33*, p. 687.

Plate III, Fig. 1

Although there is no specimen of this fine pentacrinid in the collection sent me, two were taken on the Pentacrinus ground off Havana and are briefly referred to in the "Narrative" (p. 75) as "beautiful specimens." A photograph of one of these lies before me and shows its beauty admirably.

Isocrinus decorus

Pentacrinus (Neocrinus) decorus Wyville Thompson, 1864. Intellectual Observer, *5*, p. 7.

Pentacrinus decorus P. H. Carpenter, 1884. *Challenger* Crinoids, pt. 1, pl. XXXIV.

Isocrinus decorus A. H. Clark, 1908. Proc. Biol. Soc. Washington, *21*, p. 149.

Plate I and Plate III, Figs. 2, 3

This, the most abundant of the West Indian stalked crinoids, was taken by the Bahama Expedition in great numbers on the Pentacrinus grounds off Havana, and 13 specimens were sent to me. The species has been so thoroughly studied, I have nothing to add as regards the morphology. In the "Narrative" (p. 75), Professor Nutting writes: "*P. decorus* when first out of water usually had the head gracefully drooping and the arms not greatly recurved, the outline of the whole being very much like that of a lily." It "is much more fragile than the

other species, both the cirri and arms being more slender and liable to injury. Lieutenant Commander Sigsbee reported that the colors of these pentacrini were light brown, white or yellow. We saw none that were either white or yellow, all being of some shade of light brown, usually with a purplish or violet tinge, and sometimes approaching a flesh color. Bright yellow Comatulæ were fairly abundant, and white or nearly white Comatulæ were also secured at this place. It occurs to me as possible that Lieutenant Commander Sigsbee may have had these in mind when giving the colors of the pentacrini. Several specimens lived some little time after coming on deck. The *P. decorus* would gracefully expand its arms until they assumed a reflexed attitude similar to that of *P. mülleri*. The cirri were also moved about as if seeking support, and there was some motion of the stem. We did not observe any independent motion of the pinnules. A majority of the specimens came on deck in good condition. Some were broken in the operation of disentangling from the hemp strands, and a few, not very many, were ruined by their noted proclivity to 'fly all to pieces' when displeased."

One of the most notable specimens taken on the Pentacrinus grounds was a very small individual, the whole calyx and arms only about 16 mm. high. This specimen was not sent to me but there is little reason to doubt that it is a young *P. decorus*. Although this specimen "is of peculiar interest" as Professor Nutting writes me, nothing has been published in regard to it as far as I know. Professor Nutting adds, in his letter, "Dr. Alexander Agassiz upon seeing it, thought it was at that time the youngest pentracrinus that had been secured. He made some drawings of it and sent it to a German specialist for study. I have seen no results of these studies neither have Agassiz's drawings appeared in print. This specimen we regard as so valuable that I do not like to have it leave our hands."

The list of stations where *Isocrinus decorus* was taken, as shown by the specimens at hand, is as follows:

Station 2. Cuba: off Havana, about 2½ miles, 110 fms. 5 specimens.

Station 5. Cuba: off Havana, about 2½ miles, 140 fms. 1 specimen.

Station 10 Cuba: off Havana, about 2½ miles, 200 fms. 3 specimens.

Station 11. Cuba: off Havana, about 2½ miles, 200 fms. 1 specimen.

Station 13. Cuba: off Havana, 200 fms. 1 specimen.

Station 16. Cuba: off Havana, 200 fms. 1 specimen.

No label, 1 specimen.

Democrinus rawsonii

Rhizocrinus rawsonii Pourtalès, 1874, Illus. Cat. M. C. Z., no. 8, p. 27; pl. V.

Democrinus rawsonii A. H. Clark, 1917. Jour. Washington Acad. Sci., 7, p. 392.

In the "Narrative" (p. 164), speaking of the dredging results on Pourtalès Plateau, Professor Nutting says: "We especially regretted our failure to secure specimens of Rhizocrinus, a genus which is represented by abundant individuals in certain definite spots on the Pourtalès Plateau." This disappointment would have been lessened had Professor Nutting known that the genus was represented in the collections he had made off Havana. It was a pleasant surprise to me in examining the specimens of *Isocrinus decorus* to find among them part of the stalk, with calyx attached, of an adult Bourguetocrinid, which proves to be *Democrinus rawsonii.* There is no clue as to the station at which the specimen was taken but there is no doubt of its being from the Pentacrinus ground. The stem is about 145 mm. long and consists of 60 segments. The calyx is 4 mm. high and 1.85 mm. in diameter. The sutures are nearly obliterated and were visible only when the calyx was dried and treated for a moment with benzole. The arms are entirely lacking.

ECHINOIDEA

The collection of echini sent to me consists of 381 specimens, representing 21 species. Nearly all are in excellent condition and the many young specimens are very interesting. Besides

these there are five species mentioned in Professor Nutting's "Narrative" which are not in the collection sent to me. One of these (*Dorocidaris blakei*) will be found discussed under *Cidaris abyssicola* and another (*Aspidodiadema sp.?*) under *Centrechinus antillarum.* The others are inserted each in its natural position in the list.

Eucidaris tribuloides

Cidarites tribuloides Lamarck, 1816. Anim. s. Vert., *3,* p. 56.
Cidaris tribuloides A. Agassiz, 1872. Rev. Ech., p. 253; pl. I*d* and pl. II, figs. 1-3.
Eucidaris tribuloides Döderlein, 1887. Jap. Seeigel, p. 42.

There is only a single specimen of this common West Indian cidarid in the collection before me, but in the "Narrative," the species is reported from the Tortugas (p. 132), where it "was found principally on the mud-flats just inside the reef," and from Pourtalès Plateau (p. 173). The specimen sent me is labelled "Bahama Islands." It is a fine adult, 44 mm. in diameter of test.

Cidaris abyssicola

Dorocidaris abyssicola A. Agassiz, 1869. Bull. M. C. Z., *1,* p. 253.
Dorocidaris papillata A. Agassiz, 1872. Rev. Ech., p. 254 (*in part*); pl. I, figs. 1-4.
Cidaris abyssicola H. L. Clark, 1909, Ann. Mag. Nat. Hist. (8), *3.* p. 88

An excellent series of this cidarid is in the collection, but most of the specimens are very young. They range in test-diameter from 5.5 to 37 mm. Some of the smaller specimens throw some light on the color of this species in life. The primary spines are pure white, except the very young ones near the apical disk which, while still covered with the epidermis, are brownish-red. The epidermis, while retained over the whole spine, gives it a dull, smooth, opaque appearance, very different from the mature spine. When the epidermis is first shed the spines are quite rough with longitudinal series of minute sharp teeth, but with the passage of time these wear down until in fully adult individuals the primary spines are nearly or quite smooth. In one young specimen, the test and second-

ary spines are still quite bright brownish-red but in all the other specimens this color is nearly or quite faded out and they are yellowish or white.

Mortensen (1910, Bull. 74 U. S. Nat. Mus., p. 13) has suggested a distinct variety of *abyssicola,* which he calls *teretispina,* and of which he says (p. 15) "I am inclined to think it will ultimately prove to be a distinct species." In deference to this opinion of my honored friend and colleague, I have carefully examined more than 150 specimens of *abyssicola* from ten different localities to see if I could distinguish this variety consistently. While many specimens answer perfectly to the description and figures of *teretispina,* and others are with equal certainty typical *abyssicola,* I cannot find any combination of characters by which they can be separated consistently from each other. Even the shape of the primary spines is unreliable and indeed shows great diversity. Relatively few specimens have the radioles "somewhat fusiform and attain their greatest diameter at about one-fifth the length of the spine from the base," and it is very unusual to have more than a few spines on one specimen show this character clearly. Many specimens have most of their spines cylindrical with a more or less indistinct constriction at the base, or very slightly fusiform with the largest diameter at or near the middle. Sometimes the greatest diameter of the spine is near the tip, but this is quite unusual. In one specimen a primary spine on one interambulacrum is notably stout and slightly thicker distally than proximally, while the others are slender and nearly cylindrical. Perfectly terete mature spines are very uncommon but immature spines are usually terete. Cylindrical spines, terete distally, such as characterize Mortensen's proposed variety (see his plates 9 and 10) are very common and are often found on specimens which have most of the spines more perfectly cylindrical. So far as the tuberculation of the ambulacra and the shape of the test is concerned, they are simply matters of slight individual diversity, and instead of considering *teretispina* as a potential species, I cannot even accept at as a variety worthy of recognition.

In the "Narrative" (p. 173) *Dorocidaris blakei* A. Ag. is re-

ferred to as though many specimens were secured on the Pourtalès Plateau, but Professor Nutting particularly states that the specimens "were without the peculiar fan-shaped spines or radioles which constitute the most striking peculiarity of the species." He adds: "The characters of the test were well marked however." There can be little doubt I think that these specimens were *C. abyssicola* and Professor Nutting's misidentification was most natural. It is due to the fact that Mr. Agassiz in the "Revision of the Echini," united under the name *Dorocidaris papillata* several species which we now consider quite distinct. Two of the most distinct of these are *Stylocidaris affinis* and *Cidaris abyssicola.* These were both dredged by the Iowa party on Pourtalès Plateau and as they were obviously different, the former were called *D papillata* and the latter were naturally called *blakei,* as the bare test of that species can only be distinguished with difficulty from that of *abyssicola.*

The specimens in the Iowa collection were taken as follows:

Station 39. Florida: off Key West, 20 fms. 3 specimens.

Station 54. Florida: about 15 miles off American Shoal Light, about 130 fms. Primary spines only.

Station 56. Pourtalès Plateau, 24° 16′ N. x 81° 22′ W., about 200 fms. 1 specimen.

Station 57. Pourtalès Plateau, 24° 18′ N. x 81° 18′ W., 200-225 fms. 10 specimens.

Station 58. Pourtalès Plateau, 24° 19′ N. x 81° 19′ W., about 200-225 fms. 10 specimens.

Station 62. Florida: about 8 miles off American Shoal Light, 70-80 fms. Primary spines only.

Station 64. Florida: about 8 miles off American Shoal Light, about 110 fms. 1 specimen.

Stylocidaris affinis

Cidaris affinis Philippi, 1845. Arch. Naturg. *11,* jhg. 1, p. 351. See Mortensen, 1903, *Ingolf* Ech., pt. 1, pl. I, fig. 1.

Dorocidaris papillata A. Agassiz, 1872. Rev. Ech., p. 254 (*in part*); pl. I, fig. 5.

Stylocidaris affinis Mortensen, 1909. Ech. Deutsch. Südpolar- Exp., p. 52.

This species, notable as one of the very few echinoderms common to the Mediterranean and the West Indian region, is repre-

sented in the present collection by 14 specimens, most of which are however quite young. I am satisfied that Mortensen's institution of a new genus, Stylocidaris, for this species and its near allies is advisable and I am inclined to think that his suggestion that *affinis* hybridizes with *Tretocidaris bartletti* is worthy of serious examination. Several of the specimens in the series before me have distinctly banded spines as in *T. bartletti* but their pedicellaræ are those of *affinis.* They are however quite small and the banded spines may be merely a revelation of an ancestral character or they may indicate only individual diversity. The large specimen figured by me as *T. bartletti* (1907, Bull. M. C. Z. *51*, pls. 8 and 9) which showed pedicellariæ in part like *bartletti* and in part like *affinis* is much more probably a hybrid, as Mortensen suggests.

As regards Dr. Mortensen's proposed species *Stylocidaris lineata* (1910, Bull. 74 U. S. Nat. Mus., p. 10), I have examnied not only the series before me now, but the large series in the M. C. Z. collection, in the hope of confirming my Danish friend's judgment. I am obliged to say however that I do not find the characters given at all constant. The color is the best of these, and uniformly white specimens might perhaps bear the varietal name *lineata,* if the color in life is similar to that shown by the preserved specimens. If, however, there is more or less of a reddish tinge in life, the variety would be difficult to maintain. As regards the tuberculation of the ambulacra and the length of the radioles and tridentate pedicillariæ the light and dark colored forms are not separable.

In the "Narrative" (p. 173) this species is reported naturally as *Dorocidaris papillata* A. Ag. and is said to occur on the Pourtalès Plateau "in definite spots where there were innumerable individuals." These "repeatedly came up on the tangles by the hundred and became a sore trial to our patience, the serrated spines being especially difficult to disengage from the tangles. Indeed, this labor became one of our main occupations while on the Pourtalès Plateau." The specimens sent to me are from the following stations:

Station 4. Cuba: off Havana, 110 fms. 1 small specimen with banded spines.

Station 5. Cuba: off Havana, 140 fms. 3 specimens.

Station 27. Florida: off Key West, 50-60 fms. 2 small specimens with banded spines.

Station 39. Florida: off Key West, 20 fms. 2 specimens.

Station 57. Pourtalès Plateau, 24° 18′ N. x 81° 18′ W., 200-225 fms. 2 small, nearly white specimens.

Locality unknown. 4 specimens.

Tretocidaris bartletti

Dorocidaris bartletti A. Agassiz, 1880. Bull. M. C. Z., *8*, p. 69.

Tretocidaris bartletti Mortensen, 1903. *Ingolf* Ech. p. 16. 1910, Bull. 74 U. S. Nat. Mus., pls. 2 and 3.

In the "Narrative," this handsome species is referred to as occurring both on the Pentacrinus ground, off Havana (p. 82) and on the Pourtalès Plateau (p. 173). It has been fully described and beautifully figured by Mortensen (*op. cit.*, 1910). Only two young specimens are in the collection sent to me.

Station 7. Cuba: off Havana, 140 fms. 2 specimens.

Histocidaris sharreri

Porocidaris sharreri A. Agassiz, 1880. Bull. M. C. Z., *8*, p. 71. 1883, *Blake* Ech., pl. III.

Histocidaris sharreri Mortensen, 1909. Ech. Deutsch. Südpolar- Exp., p. 55.

Plate IV, Fig. 1

On p. 82 of the "Narrative," Professor Nutting says, in speaking of the Echini taken on the Pentaerinus ground, off Havanna: "Perhaps the handsomest species was *Porocidaris sharreri,* one specimen being a truly magnificent one, with spines about seven inches in length, and the peculiar serrated radioles resembling some of the ivory spear-heads used in Africa." On my writing Professor Nutting that two species have been confused under the name *Porocidaris sharreri* and inquiring about this specimen from the Pentacrinus grounds, he replied: "I am practically certain it is the true *P. sharreri.* We have the specimen here. It is one of those about which I wrote, saying that there were certain specimens in our exhibit series that it would be inconvenient to send and that I would have them photographed. This I have done and a very good

photograph was included in those recently sent you...... You will see that the prominent primary spines are not smooth but jagged, with thorn-like processes. I remember very well the color of this specimen when fresh and it was that of the true *P. sharreri.* Had it exhibited the 'exquisitely tinted pink and apple-green' that you speak of*, I am sure I would have noted it.'' The photograph sent me shows that this specimen has much more slender spines than the individual figured in the *Blake* report but many of them flare and are fluted at the tip in characteristic fashion. The measurements of the specimen are approximately 60 mm. in test diameter, nearly 50 mm. in height, and 155 mm. in length of longest spine.

There can be no doubt then of the occurrence of this fine species off Havana, as well as off Georgia and off Barbados. There is no specimen in the series sent to me.

Salenia pattersoni

A. Agassiz, 1878. Bull. M. C. Z., *5*, p. 187. 1883, *Blake* Ech., pl. V.

Plate V

There are 12 specimens of this lovely sea-urchin taken on the Pentacrinus grounds, off Havana, but there is no label showing the exact station or depth. In the ''Narrative'' (p. 82) Professor Nutting says this ''species, with spines banded with vermilion and white, is rendered still more attractive by bands of deep violet following the ambulacral furrows and outlining the plates of the apical system, the ground color being a dove or cream color.''

Arbacia punctulata

Echinus punctulatus Lamarck, 1816. Anim. s. Vert., III, p. 47.
Arbacia punctulata Gray, 1835. Proc. Zool. Soc. London, p. 38. A Agassiz, 1872. Rev. Ech., pl. II, fig. 4.

In the ''Narrative'' (p. 98), in speaking of the sea-urchins found at Bahia Honda, Cuba, Professor Nutting says: ''*Arbacia punctulata* was the only other echinoid found here in abundance.'' This is remarkably interesting for the genus was not

*The colors in part of **Calocidaris micans.**

known from the southern or eastern side of the Gulf Stream, north of Tobago. It has long been supposed that *punctulata* does not occur in the West Indies, but that it ranges from Yucatan and the Tortugas, northward to Massachusetts. It is true that in the Revision, Mr. Agassiz refers to specimens from Hayti in the M. C. Z. collection but such specimens are not now to be found and it is quite possible that there is some mistake. In March and April, 1916, I was surprised to find *punctulata* at Buccoo Bay, Tobago; and later, I saw in the collection of Mr. R. J. L. Guppy, of Port-of-Spain, Trinidad, specimens which he had taken in the Gulf of Paria many years before. Mr. Guppy called my attention to the fact that the species was listed by him (as *Echinocidaris punctulata*) in 1895 in an article on the Echinoderms of the Gulf of Paria (Proc. Victoria Inst. Trinidad, pt. 2, p. 115).

Unfortunately the specimens of Arbacia sent me in the Bahaman collection are either from the Pourtalès Plateau of Florida, or have no locality label, and I have not yet seen therefore any authentic West Indian specimens from north of Tobago. The specimens with simply the label "West Indies" are probably from Bahia Honda but there is no direct evidence of the fact. They are notable for their very slender spines. The smallest is 16 mm. in diameter and has spines 20 mm. long and .80 mm. thick, while the largest is 25 mm. in diameter and has spines 22 mm. long and 1 mm. in diameter. In none of the five Arbacias before me is there an ocular plate insert.

Station 27. Florida: off Key West, 50-60 fms. 1 very young specimen.

Florida: The Tortugas, Sand Key. 1 specimen.

West Indies. 3 specimens.

Cœlopleurus floridanus

A. Agassiz, 1872. Rev. Ech., p. 102. 1883, *Blake* Ech., pl. VII.

This very remarkable and very characteristic West Indian sea-urchin was met with by the Bahama Expedition on both sides of the Gulf Stream. Most of the specimens before me are quite small (under 20 mm. in test diameter) but one is fully grown and measures 44 mm. through the test; all of the pri-

mary radioles are broken but the longest piece remaining measures 57 mm. The smallest specimen is only 9 mm. in diameter but the radioles are 29 mm. long. Of the 13 specimens, 11 have 4 anal plates, 1 has 3 and 1 has 5. Both of these latter specimens are referred to by Professor Nutting in the "Narrative" (p. 83), where he speaks of this "beautifully colored species" which "made a pleasing display with its brilliant crimson and white spines." These individuals were taken on the Pentacrinus ground off Havana but the same species was found on the Pourtalès Plateau and of these, it is said (p. 173) they were "probably the most beautiful of the true sea-urchins collected at this time, some specimens being considerably larger than those secured off Havana. Not only are the long, slender spines brilliantly colored with carmine and white or orange, but the test itself is equally striking with its alternate chocolate and orange zones, making it resemble, the gorgeously colored balls in which children delight."

Station 5. Cuba: off Havana, 140 fms. 1 specimen.

Station 26. Florida: off Key West, 60 fms. 1 large specimen.

No label, but apparently Cuba: off Havana, Pentacrinus grounds, 110-200 fms. 11 specimens.

Centrechinus antillarum

Cidaris (*Diadema*) *antillarum* Philippi, 1845. Arch., Naturg., jhg. 11, *1*, p. 355.

Diadema setosum A. Agassiz, 1872. Rev. Ech., p. 274. (*in part*).

It is of course to be regretted that the name Diadema, which has been in use for many years for this most common and easily recognized, and unfortunately most to-be-dreaded West Indian sea-urchin, must be abandoned, but there can be no doubt that Jackson (1912, Phylogeny Ech., p. 27) was absolutely right in rejecting that preoccupied name and proposing the highly appropriate and euphonious name, Centrechinus, in its stead. Dr. Mortensen, whose opinion is entitled to more weight perhaps than that of any other student of echini, disagrees with me very decidedly on this point and refuses positively to give up Diadema. He holds strongly to the view that Diadema is one of those long-used names which should be arbitrarily maintained

by means of a list of *nomina conservanda,* adopted by international agreement. To this I should make no objection whatever and if it ever is done, I will cheerfully take up Diadema again. Meanwhile it seems to me that Centrechinus is the only correct name for this genus of long-spined, poisonous black sea-urchins.

Mr. Agassiz did not distinguish between the species of the East and West Indies, in the Revision, but later (1908, Mem. M. C. Z., *34* p. 112) he came to agree with Mortensen in recognizing half a dozen species, and in restoring Philippi's name to that of the West Indies.

This is unquestionably the most conspicuous and generally known of the West Indian sea-urchins but oddly enough it has never been adequately figured. The photographs of *Diadema setosum* given in the Revision are not taken from West Indian specimens. The little drawing (fig. 1) on the plate opposite p. 224 in the "Narrative", and labelled *"Aspidodiadema sp."* gives as good an idea of the appearance of this sea-urchin in life as any figure I can find. This figure is a life-size drawing of a young Centrechinus; and except for the banded spines would, if magnified three or four times, represent the adult equally well. It is an interesting fact that the young of this species always have the spines prettily banded with purplish-violet and white. They thus look very unlike the adults and it is not strange that they are often mistaken for a different species. In the "Narrative" (pp. 83, 223) these pretty little long-spined urchins are referred to as Aspidodiadema of uncertain species. The specimens in the collection sent me are also labelled Aspidodiadema. These young specimens of Centrechinus are referred to in the "Narrative" as occurring at the Pentacrinus ground off Havana (p. 83) and near Little Cat Island, Bahamas (p. 223). Adult examples were found at Egg Island, Bahamas (p. 45), the Tortugas, Florida (p. 132) and at Spanish Wells, Eleuthera Island, Bahamas (pp. 202, 213). Professor Nutting's field notes on the very painful stinging powers of the spines (p. 132) and of the possible use of the jaws in rock-boring (p. 213) are of great interest and value but are too extended to warrant repetition here. The specimens of Centrechinus in the Iowa collection are as follows:

Bahamas: Little Cat Island. 4 small specimens, 16-25 mm. in diameter, with banded spines 50 mm. long.
Bahamas: Eleuthera Island, Spanish Wells, 2 adults.
Bahamas: no definite locality, 1 adult.
No locality label. 5 small specimens, 10-18 mm. in diameter, with banded spines, 22-30 mm. long.

Aræosoma fenestratum

Calveria fenestrata Wyville Thomson, 1872. Proc. Roy. Soc. London, *20*, p. 494.
Asthenosoma hystrix A. Agassiz, 1883. *Blake* Ech., pls. XIII and XIV.
Araeosoma fenestratum Mortensen, 1903. *Ingolf* Ech., pt. 1, p. 52.

Plate IV, Fig. 2

In the "Narrative" (p. 173), there is an interesting account of the capture of an adult specimen of this remarkable sea-urchin on the Pourtalès Plateau in 105 fms., which is referred to as "the largest sea-urchin secured during the entire cruise." "This specimen was seven inches across the test and was swollen out, when it came on deck, to the regulation out-line of a sea-urchin." It was soon discovered "that it was not an animal to be handled with impunity, as its spines, although small, were exceedingly sharp and inflicted a wound so painful as to suggest some poisonous properties. The specimen was of a dull vinaceous color."

A photograph of this specimen, now 6 inches in diameter and 2 inches high, has been sent me but I have not seen the specimen. I have no doubts however of the identification.

There is, in the collection before me, a very young echinothurid, labelled "*Phormosoma placenta*" but with no locality indicated, which I think is the young of this species. It is only 22 mm. across and is somewhat damaged but there is little doubt it is an Aræosoma. The spines of the upper surface are notably long and relatively more numerous than in larger specimens and the color is rusty-red. This color, however, may have been artificially produced, after preservation.

Cænopedina cubensis

A. Agassiz, 1869. Bull. M. C. Z., *1*, p. 256. 1872, Rev Ech,, pl. III, figs. 1-7 (as *Hemipedina cubensis*).

The Bahama Expedition was so fortunate as to secure two specimens of this very rare sea-urchin. One of these (St. 58) is an unusually fine specimen, 22 mm. in diameter; the primary spines are 27 mm. long but all are broken at the tip; they are of a yellow-green color while all the smaller ones are white. This is the largest specimen I have seen but Koehler (1909, *Princesse-Alice* Ech., pl. 1, fig. 1) gives a fine colored figure of a specimen about 35 mm. in diameter, with primary spines 66 mm. long. The second specimen secured by the Bahama Expedition is only 13 mm. in diameter and has lost all of its spines.

This species is not referred to in the "Narrative" of the expedition, and there are few references to it elsewhere in literature. It is not included in the *Blake* report among the echini taken by the *Blake* but there is a small specimen in the M. C. Z. taken at *Blake* St. 320, off Georgia, in 257 fms. According to Verrill (1885, *Albatross* Expl., p. 49) the *Fish-Hawk* took a specimen in 1882 off the eastern coast of the United States in 194 fms. The only station occupied by the *Fish-Hawk* in 1882, with a depth of 194 fms. was near Nantucket. The *Princess-Alice* took one specimen in 1901 near the Canary Islands in 610 fms. and two specimens in 1902 near the Azores Islands in 659 fms. Evidently the species is widespread in the North Atlantic but in much deeper water on the eastern side than near the American coast.

In my key to the species of Cænopedina (1912, Mem. M. C. Z., *34*, p. 217) there is a very unfortunate *lapsus calami* which vitiates one of the distinctions between *C. cubensis* and *C. indica*. The comparison made between "actinostome" and "periproct" should be between actinostome and the *entire abactinal system*. In *cubensis*, the actinostome is distinctly smaller than the abactinal system, while in *indica* they are of about equal size.

The Bahama Expedition took *cubensis* at the following places:

Station 58. Florida: on the Pourtalès Plateau, 24° 19′ N. x 81° 19′ W., about 200-225 fms. 1 fine specimen.

Locality unknown, 1 bare test.

Echinus gracilis

A. Agassiz, 1869. Bull. M. C. Z., *1*, p. 269. 1872, Rev. Ech., pl. VI*a*, fig. 6.

This is one of the characteristic species of the Pourtalès Plateau, where, Profesor Nutting says (p. 174) it is, next to *Stylocidaris affinis*, the most abundant species of sea-urchin. He also says it is the largest species from the region, except *Araeosoma fenestratum*. All the specimens sent to me however are small, ranging from 6 to only 24 mm. in diameter. They are of great interest, nevertheless, as showing the changes which take place during growth in this very handsome species. The changes in color are of course the most obvious. The smallest specimen is nearly all white but the genital plates and the three or four uppermost interambulacral plates show sufficient green (dull olive in dried specimens) to form a more or less distinct star on the center of the abactinal surface. In slightly larger specimens the *inner* ends of the uppermost ambulacral plates are green and in specimens 10 mm. in diameter the green has extended to the ambitus; in the interambulacra, the upper part and both ends of each plate are more or less fully and deeply green, while in the ambulacra, the green occupies all the inner half of each plate, leaving the primary tubercle and poriferous area white. The ocular and genital plates are more or less variegated with green but the periproctal plates as a rule remain white; occasionally they too are greenish however. This is essentially the coloration of the adult, though the green may in large specimens extend well down onto the actinal surface.

There is little change in the ambulacra during growth, the adult plates remaining remarkably primitive, and the plating of the peristome remains about the same in the larger specimens as it is in the smallest. But the relative size of the peristome decreases rapidly as is usual in the genus Echinus. Thus the specimen 6 mm. in diameter has a peristome 3.5 mm. across or nearly .60 of the test; one 10 mm. in diameter has the peristome 5 mm. or .50; one 17 mm. has the peristome 7 mm. or only a

little over .40; and the largest, 24 mm. has a peristome only 8 mm. or .33. Large specimens have the peristome often under .30 of their horizontal diameter.

Another interesting growth change is in the plating of the periproct. In the smallest specimen, the suranal plate covers the periproct almost completely, just as it does in adult *Genocidaris maculata.* In specimens a little larger, there are three other periproctal plates; the four plates have the relative size and position of those in adult *Trigonocidaris albida,* though the suranal may be relatively larger. In a specimen 8 mm. in diameter, there are eight periproctal plates, but the suranal is much the largest. The number of plates then increases and the relative size of the suranal decreases until, in a specimen 17 mm. in diameter, there are 14 plates and the suranal covers only about one-fourth of the periproct. In the adult (43 mm. in diameter), there are about twenty plates and except for its position the suranal is scarcely distinguishable.

The specimens in the Iowa collection were taken at the following places:

Station 57. Pourtalès Plateau, 24° 18′ N. x 81° 18′ W., 200-225 fms. 29 specimens.

Station 58. Pourtalès Plateau, 24° 19′ N. x 81° 19′ W., about 200-225 fms. 1 specimen.

Station 64. Florida: off American Shoal Light, 110 fms. 1 specimen.

Locality unknown. 11 specimens.

Lytechinus euerces

H. L. Clark, 1912. Mem. M. C. Z., *34*, p. 247; pl. 107, figs. 4-6.

It is interesting to find half a dozen specimens of this species in the Iowa collection but it is most unfortunate that there is no locality label, so there is no clue to the depth at which they were taken. As they were mixed with *Trigonocidaris albida, Echinus gracilis* and *Genocidaris maculata,* it is fairly certain that they were collected with those three species on Pourtalès Plateau. They are all young, the test-diameter being only 10-15 mm. For the differences between this species and those with which it occurs see below (p. 33) under Genocidaris.

Lytechinus variegatus

Cidaris variegata Leske, 1778. Add. ad Klein, p. 85.
Lytechinus variegatus A. Agassiz, 1863. Bull. M. C. Z., *1*, p. 24.
Toxopneustes variegatus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 298; pl. IV*a*, figs. 5, 6.

This, the most abundant of West Indian echini, except perhaps Centrechinus, is represented in the collection before me by only 7 specimens, 3 small adults from Bahia Honda, Cuba, and 4 young without locality but evidently from the Cuban coast also.

Lytechinus variegatus carolinus

Lytechinus carolinus A. Agassiz, 1863. Bull. M. C. Z., *1*, p. 24. 1872, Rev. Ech., pl. II, figs. 5, 6 (as *Toxopnenstes variegatus*).
Lytechinus variegatus carolinus H. L. Clark, 1912. Mem. M. C. Z., *34*, p. 245.

It is rare indeed that trinomials, indicating geographical subspecies, can, in the present state of our knowledge, be used among echinoderms, but *Lytechinus variegatus* is a remarkably clear case. Specimens from the northern and western sides of the Gulf usually have the spines so much stouter and shorter, relatively, than those of the specimens from Cuba, Jamaica and eastward, and their color is so pink that they look very different. But intergradations are so common and indubitable that the relation is best shown by trinomials. A third form (*atlanticus*) is well differentiated in the Bermudas.

The Iowa collection contains five small, poor specimens of this subspecies, ranging in disk diameter from 6 to 10 mm. The locality is not indicated, except that two are labelled "West Indies." They are all probably from the Tortugas.

Tripneustes esculentus

Cidaris esculenta Leske, 1778. Add. ad Klein, p. XVII.
Hipponoë esculenta A. Agassiz, 1872. Rev. Ech., p. 301; pl. VI*a*, figs. 1-3.
Tripneustes esculentus Bell, 1879. Proc. Zool. Soc. London, p. 657.

Of the 7 specimens of this common species, only one deserves any comment. It is one of the smallest specimens of this big "sea-egg" (the West Indian native name) which I have ever

seen. It is about 7 mm. in diameter and 4 mm. high and is denuded of all its spines. The peristome is relatively very large as it is about 3.75 mm. across; except for the primordial ambulacrals it is almost completely free from plates. The abactinal system is less than 3 mm. across but ocular I is broadly insert. The ambulacra are very simple and quite echinoid with the pores in regular arcs of 3; the only peculiarity is that, above the ambitus, every other primary ambulacral tubercle on each side is distinctly smaller or may even be suppressed.

In the "Narrative", this species is referred to as occurring at the Tortugas (p. 133) where it is said to be "much larger" than in the Bahamas. In the latter region, it is referred to as occurring at a flat bar near the mainland of Eleuthera (p. 202) and at Spanish Wells (p. 213). On pp. 213 and 214, Professor Nutting records some very interesting and important observations which go to show that this sea-urchin exercises "choice" and has at least a rudimentary "memory."

Bahamas: Eleuthera Island, Spanish Wells. 4 adult specimens.

Bahamas: Eleuthera Island, Harbor Island. 2 adult specimens

Locality unknown. 1 very small specimen.

Trigonocidaris albida

A. Agassiz, 1869. Bull. M. C. Z., *I*, p. 263. 1872, Rev. Ech., pl. IV, figs. 1-7.

In the "Narrative" (p. 174) Professor Nutting speaks of this pretty little sea-urchin being abundant on the Pourtalès Plateau. There are nearly a hundred specimens in the collection but the great majority lack a locality label. There is no doubt however that they are from the Pourtalès Plateau. They range in diameter from 6 to 13 mm., the latter being about the maximum size for the species. The growth changes after the diameter is 6 mm. seem to be very slight. Even the peristome shows only a small relative decrease; it is 3 mm. across (50%) in the smallest specimen and 5.5 mm. (42%) in the largest. The amount of sculpturing on the test does not seem to vary

with age or size, but is subject to very great individual diversity.

As this little echinoid is known not only from the West Indian region but from the Hawaiian Islands and Dutch East Indies as well as from the eastern Atlantic, it seems to have a world wide distribution in the tropics.

Station 54. Florida: 15 miles off American Shoal Light, about 130 fms. 2 specimens.

Station 57. Pourtalès Plateau, 24° 18′ N. x 81° 18′ W., 200-225 fms. 7 specimens.

Station 64. Florida: about 8 miles off American Shoal Light, about 110 fms. 1 specimen

Locality unknown. 84 specimens.

Genocidaris maculata

A. Agassiz, 1869. Bull. M. C. Z., *I*, p. 262. 1872, Rev. Ech., pl. VIII, figs. 1-18.

This species occurs in abundance on Pourtalès Plateau ("Narrative" p. 174) and was also found on the Pentacrinus ground near Havana (p. 83). The range of this little urchin is remarkable, extending across the Atlantic and far into the Mediterranean, and southward on the African coast to the region of the Congo. The specimens in the Iowa collection are nearly all from an unknown locality, presumably some station or stations on the Pourtalès Plateau. They range in size from 3 to 12 mm. diameter. The growth changes between these two extremes are not remarkable, the peristome decreasing only from 50 per cent to about 45 per cent. Even in the largest the periproct is practically all covered by the single suranal plate. The general coloration is more or less light greenish abactinally, becoming nearly pure white below. In some individuals, there is a more or less elongated blotch of light purplish-brown, in each interambulacrum near the abactinal system; this may extend to the ambitus or there may be a second blotch at the ambitus. In many individuals these, and other scattered blotches, are distinctly green in tint. These blotches, from which the specific name, *maculata,* arises are rarely absent even in very young specimens. In the larger specimens, the basal part of all the

primary spines above the ambitus is distinctly pink and most of the larger primaries have one or two bands of brownish-pink at the middle or distally; these bands are however very faint and might easily pass unnoticed.

This species and the preceding are so easily confused with the young of Echinus, Lytechinus and even Tripneustes that the following key will be useful to those who have occsaion to sort small West Indian echini. It is based largely upon the material before me in the Iowa collection.

Buccal membrane thin and perfectly naked or at most with widely scattered calcareous granules, in addition to the five pairs of buccal plates.

- Periproct covered almost wholly by the huge suranal plate; ocular plates all exsert; general tint of coloration greenish .... *Genocidaris maculata*
- Periproct with many small plates and no conspicuous suranal; ocular I insert; general tint pinkish or pure white.................. *Tripneustes esculentus*

Buccal membrane usually heavily plated or at least with numerous plates in addition to the buccal plates

- Abactinal system large (about .40 test diameter), flat, smooth and shining; ocular plates equally exsert; periproct covered by 4 plates, the suranal distinctly largest; test depressed and usually more or less sculptured .... *Trigonocidaris albida*
- Abactinal system smaller (.30-.35 test diameter), not flat, smooth and shining; ocular I often nearly or quite insert; periproct with 6 or more plates; test not depressed and never sculptured.
  - Buccal membrane not heavily plated but with numerous small thin plates; green color in ambulacra abactinally, confined to *inner* side of the series of primary tubercles, the whole inner end of each plate being more or less green; ocular I never insert....... *Echinus gracilis*
  - Buccal membrane heavily plated; ocular I often insert or more nearly so than the others.
    - Test white and light yellow-green, the green color in ambulacra abactinally, confined to *outer* side of the series of primary tubercles .... *Lytechinus euerces*
    - Test white and green, but the color in ambulacra occupies more or less nearly all the plates .... *Lytechinus variegatus*
    - Test pinkish or pale brown, with no indications of green .... *Lytechinus variegatus carolinus*

Some of the differences in the above key may seem trivial but they are surprisingly constant. Of course there are additional and often much more important differences than those here given; these are selected because they are so easily seen. The most common confusion is between *Trigonocidaris* and *Lytechinus euerces* and specimens of equal size, especially if under 10 mm. in diameter are often hard to distinguish. But the flattened and sculptured test of Trigonocidaris, with its large shiny abactinal system and 4 periproctal plates are generally distinctive. There may be added however, as additional features, the lack of any distinct green in the coloration and the fact that the white actinal spines are commonly encircled with a broad red band. Very small specimens of *euerces* have no green in the coloration but there is little or no red on the actinal spines. The pretty coloration of *Echinus gracilis* is very distinctive even in young specimens. Probably *Genocidaris* is the most easily recognized of the small echini; the huge suranal plate, together with the distinctive coloration, the test-sculpture and the naked buccal membrane, make it a well-marked form. The specimens of *Genocidaris* in the Iowa collection are from the following places:

Station 27. Florida: southeast of Sand Key Light, 50-60 fms. 1 specimen.

Station 48. Florida: southeast of Key West Light, about 80 fms. 1 specimen.

Locality unknown. 112 specimens.

Echinometra lucunter

Echinus lucunter Linnè, 1758. Sys. Nat. ed. 10, p. 665.

Echinometra subangularis A Agassiz, 1872. Rev. Ech., p. 283, pl. *Xa*, figs. 2-4.

Echinometra lucunter Lovén, 1887. Ech. Linnæus, p. 157.

This very common sea-urchin is only mentioned twice in the "Narrative", where it is spoken of as being found at the Tortugas (p. 133) and on Pourtalès Plateau (p. 174) in shallow water. The specimens before me are from the following places:

Bahamas: Eleuthera, Harbor Island, 1 specimen.

Bahamas: Little Cat Island. 1 specimen.

Florida: The Tortugas, Sand Key. 5 specimens.
"West Indies." 7 specimens.

Echinometra viridis

A. Agassiz, 1863. Bull. M. C. Z., *I*, p. 22. 1872. Rev. Ech., pl. X*a*, fig. 1,

It is unfortunate that Mr. Agassiz's figure represents the less common thick-spined variety of this rather uncommon species. On the reefs at the Tortugas, the differences between *viridis* and *lucunter* are very marked and no collector familiar with sea-urchins would confuse them. But after the colors have become dull and faded, the differences are less marked and in photographs the two species might easily be mixed. In the number of pore-pairs in an arc however, the two are constantly different and in photographs as good as those on plate X *a* of the Revision this difference is easily seen with a lens. In life, *viridis* is light brown, usually with a yellowish tinge but not uncommonly reddish; the primary spines are pale brownish at base, rapidly becoming greenish and quite evidently green distally, but tipped rather abruptly with bright purple; the very tip of the spine is sometimes whitish in marked contrast to the purple; the milled ring at the base of the spine is conspicuously white. The largest specimen of *viridis* I have seen is 42 mm. long and 36 mm. wide; it is the stout-spined form, the primaries being only 18 mm. long and fully 2 mm. thick while in the usual form, spines 18-20 mm. long are only about 1 mm. thick. At the ambitus, there are 5 pore-pairs in an arc, but below, there are only 4; abactinally, clear to the ocular plate, there are but 5 pairs in each arc. This arrangement of pore-pairs is characteristic of the species and is well shown in much smaller specimens. In *E. lucunter,* on the contrary, the full number of pore-pairs is 6 and if (in a small individual) there are only 5 pairs at the ambitus, some of those above the midzone will show the characteristic 6. There is only one specimen of *viridis* in the Iowa collection and it was taken at the Tortugas. The species is known only from Florida, Jamaica and Hayti. I did not find it at Tobago in 1916, although particular search was made for it.

Clypeaster rosaceus

Echinus rosaceus Linné, 1758. Syst. Nat. ed. 10, p. 665.
Clypeaster rosaceus Lamarck, 1801. Syst. Anim. s. Vert., p. 349.
Echinanthus rosaceus A. Agassiz, 1872. Rev. Ech., p. 311; pl. XI *d*, figs. 1 and 2.

In the "Narrative", this species is referred to as abundant on the Great Bahama (p. 53) and as "found in limited numbers" near Bird Key, Tortugas (p. 133). There are two large specimens in the collection labelled Bahama Banks, May 17, 1893.

Clypeaster subdepressus

Echinanthus subdepressa Gray, 1825. Ann. Phil., *26*, p. 427.
Clypeaster subdepressus Agassiz, 1836. Mem. Soc. Sci. Nat. Neuchatel, *1*, p. 187. A. Agassiz, 1872. Rev. Ech., pl. XI *b*.

No specimen of this large clypeaster is in the collection, but in the "Narrative" (p. 174), Profesor Nutting says that it was dredged on Pourtalès Plateau in 60 fms. It may be well to note here that while *C. rosaceus* and *C. subdepressus* are the common West Indian clypeasters, there are now recognized at least *four* other species in the West Indian region. Little however is known of either their distribution or growth changes and specimens of all are much to be desired. An artificial key to the Recent species of *Clypeaster* is to be found in Mem. M. C. Z., *46*, pp. 22-25.

Palæotropus josephinæ

Loven, 1872. Oefv. Vet. Akad. Förh. f. 1871, no. 8, p. 21. A. Agassiz, 1883. Mem. M. C. Z., *10*, p. 53; pl. XXIII, figs. 5-14; also pl. XXIV, figs. 6-15 (as *Palaeobrissus hilgardi*).

Although the collection contains but a single specimen of this uncommon spatangoid, the "Narrative" (p. 174) refers to its occurrence on Pourtalès Plateau in 110-220 fms. as though it were met with more than once. The specimen at hand is nearly bare, 20 mm. long, and has a distinct subanal fasciole and only 2 genital pores. It is thus still immature, as the adult, originally described as *Palaeobrissus hilgardi*, has 4 genital pores, no subanal fasciole and is over 45 mm. long. The growth changes

in this species are most interesting and a large series of specimens is greatly to be desired.

Station 52. Florida: about 10 miles off American Shoal Light, 105-110 fms. 1 specimen.

Meoma ventricosa

Spatangus ventricosus Lamarck, 1816. Anim. s. Vert., *3*, p. 29.
Meoma ventricosa Lütken, 1864. Vid. Med. f. 1863, p. 120 A. Agassiz. 1872, Rev. Ech., pl. XXII, figs. 3 and 4.

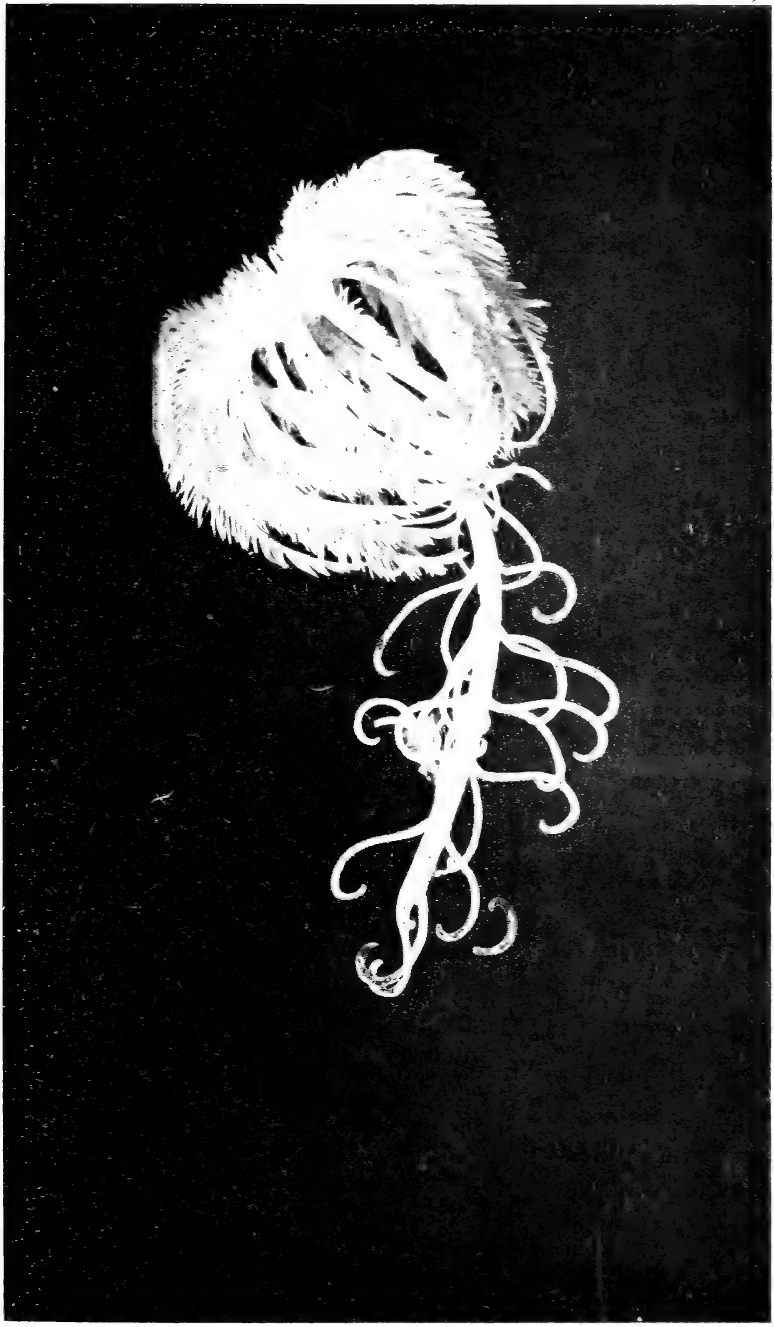
This conspicuous West Indian spatangoid is not mentioned in the "Narrative" but there is a large, bare test in the collection, from Eleuthera Island, Bahamas. It measures 160 mm. long, 125 mm. wide and 77 mm. high. This is an unusually large size but by no means the maximum. The largest specimen I have seen (M. C. Z. no. 3159) is 175 mm. long, 152 mm. broad and 90 mm. high.

Plagiobrissus grandis

Echinus grandis Gmelin, 1788. Sys. Nat. ed. 13, *1*, pt. 6, p. 3200.
Metalia pectoralis A. Agassiz, 1872. Rev. Ech., p. 361; pl. XXI, figs. 4 and 5.
Plagiobrissus grandis H. L. Clark, 1917. Mem. M. C. Z., *46*, p. 207.

There is no specimen of this truly magnificent spatangoid, common in some parts of the Bahamas, in the Iowa collection, but in the "Narrative" (p. 134) it is stated that "a portion of the test of a *Metalia* was picked up near Bird Key." The species is not otherwise known from the Tortugas but as it is known from the west coast of Florida (Tampa Bay), it will probably be found there some day.

PLATE II.



Endoxocrinus parræ (x½)

PLATE III.

Fig. 1 Isocrinus asteria (x$\frac{1}{2}$)

Fig. 2 Very young specimen of Isocrinus decorus (x3$\frac{1}{2}$)

Fig. 3 Same specimen (x1)

PLATE IV.

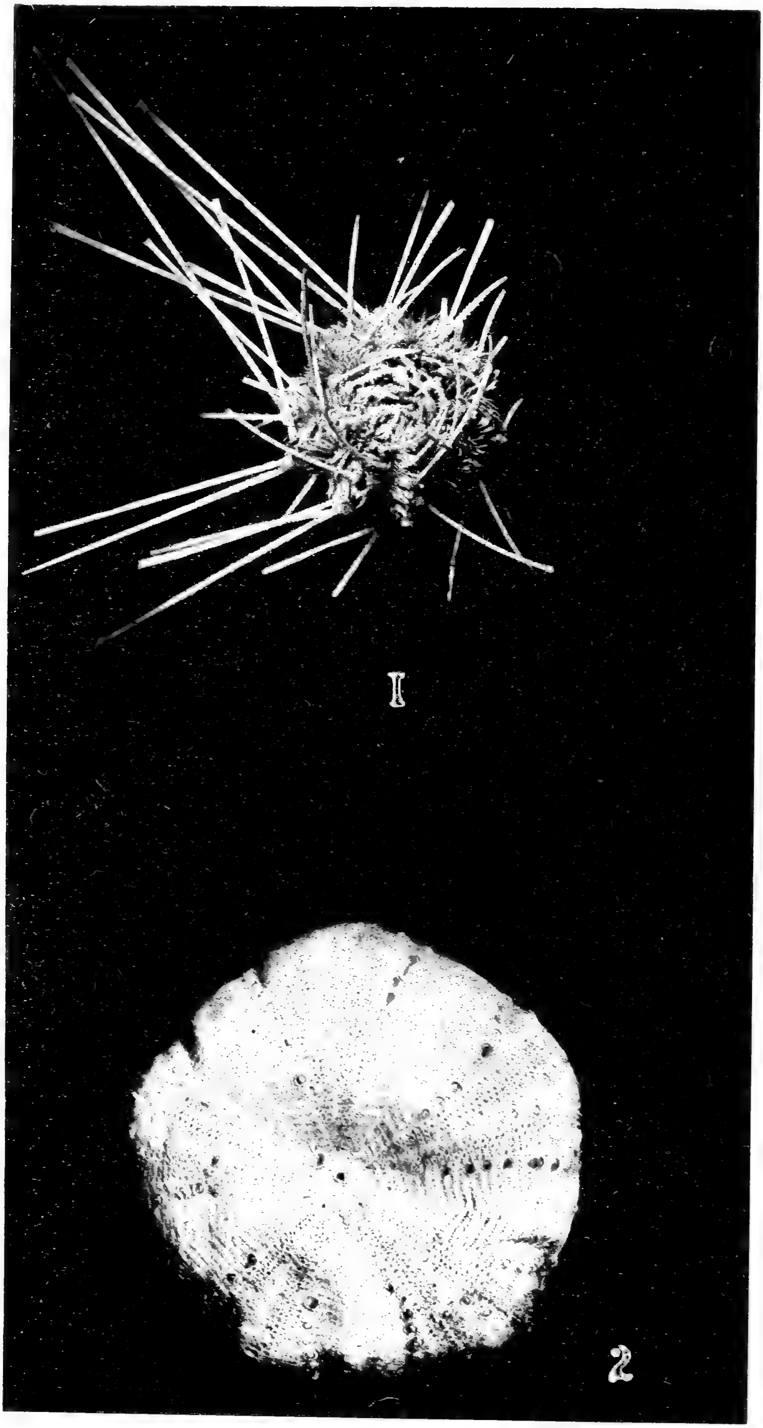
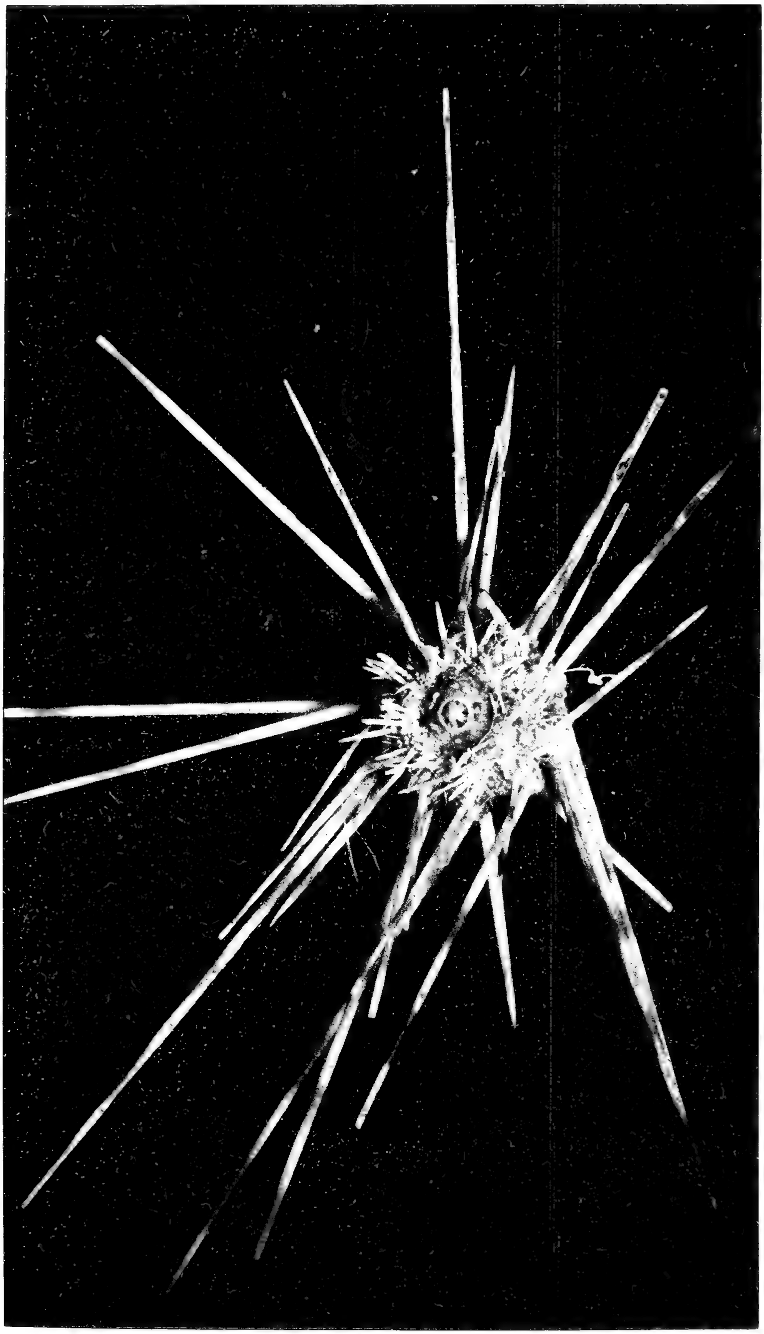


Fig. 1 Histocidaris sharreri, oral view (x2/5)
Fig. 2. Aræosoma fenestratum, aboral view, without spines

PLATE V.



Salenia pattersoni, oral view (x2)

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